

Cleveland and Canton-Massillon, Ohio Area Designations for the 2012 Primary Annual PM_{2.5} National Ambient Air Quality Standard

Technical Support Document

1.0 Summary

In accordance with Section 107(d) of the Clean Air Act (CAA), the EPA must promulgate designations for all areas of the country. In particular, EPA must identify those areas that are violating a National Ambient Air Quality Standard (NAAQS) or contributing to a violation of the NAAQS in a nearby area. EPA must complete this process within 2 years of promulgating a new or revised NAAQS, or may do so within 3 years under circumstances not relevant to these designations.¹ This technical support document (TSD) describes the EPA's intent to designate areas in Ohio as nonattainment for the 2012 primary annual fine particle NAAQS (2012 annual PM_{2.5} NAAQS), except that the Cincinnati area is addressed in a separate TSD.²

Under section 107(d), states are required to submit area designation recommendations to the EPA for the 2012 annual PM_{2.5} NAAQS no later than 1 year following promulgation of the standard, or by December 13, 2013. In December 2013, Ohio recommended that the counties identified in Table 1 be designated as "nonattainment" for the 2012 annual PM_{2.5} NAAQS based on air quality data from 2011-2013.

After considering these recommendations, and based on EPA's technical analysis as described in this TSD, the EPA intends to designate the areas listed in Table 1 as nonattainment for the 2012 annual PM_{2.5} standard. EPA must designate an area nonattainment if it has an air quality monitoring site³ that is violating the standard or if it has sources of emissions that are contributing to a violation of the NAAQS in a nearby area. Legal descriptions (e.g., county boundaries, townships, and ranges) of these areas are found below in the supporting technical

¹ Section 107(d) of the CAA requires the EPA to complete the initial designation process within 2 years of promulgation of a new or revised NAAQS, unless the Administrator has insufficient information to make initial designation decisions in the 2-year time frame. In such circumstances, the EPA may take up to 1 additional year to make initial area designation decisions (i.e., no later than 3 years after promulgation of the standard).

² On December 14, 2012, the EPA promulgated a revised primary annual PM_{2.5} NAAQS (78 FR 3086, January 15, 2013). In that action, the EPA revised the primary annual PM_{2.5} standard, strengthening it from 15.0 micrograms per cubic meter (µg/m³) to 12.0 µg/m³.

³ In accordance with 40 CFR 50 Appendix N, PM_{2.5} measurements from the primary monitor and suitable collocated PM_{2.5} FRM, FEM or ARMs may be used in a "combined site data record" to establish a PM_{2.5} design value to determine whether the NAAQS is met or not met at a particular PM_{2.5} monitoring site.

analysis for each area. As provided in CAA section 188(a), the EPA will initially classify all nonattainment areas as “Moderate” nonattainment areas.

Table 1. Ohio’s Recommended Nonattainment Areas and EPA’s Intended Designated Nonattainment Areas for the 2012 annual PM_{2.5} NAAQS

Area	Ohio’s Recommended Nonattainment Counties	EPA’s Intended Nonattainment Counties
Canton-Massillon, OH	Stark	Stark, Summit, Wayne (partial)
Cleveland, OH	Cuyahoga	Cuyahoga, Lake, Lorain
Cincinnati-Hamilton, OH-KY	Butler, Clermont, Hamilton	OH: Butler, Clermont, Hamilton, Warren (partial) KY: Boone (partial), Campbell (partial), Kenton (partial)

*Cincinnati-Hamilton is a multi-state nonattainment area composed of counties and/or partial counties in Ohio and Kentucky. The technical analysis for this multi-state area is discussed in a separate Technical Support Document.

In its recommendation letter, Ohio recommended that EPA designate as attainment all counties not identified in the Ohio Recommendation column of Table 1. EPA agrees with Ohio’s recommendations except as to Lake County, Lorain County, and Summit County, and parts of Wayne County and Warren County, as listed in Table 1. EPA intends to designate the remainder of Ohio as unclassifiable/attainment based on ambient monitoring data collected during the 2011-2013 period showing compliance with the 2012 annual PM_{2.5} NAAQS and the EPA’s assessment that areas within the State are not likely contributing to nearby violations.^{4,5}

⁴ Unless a state or tribe has specifically identified jurisdictional boundaries in its area recommendations, when determining “remainder of the state,” EPA will use Federal Information Processing Standard (FIPS) codes maintained by the National Institute of Standards and Technology (NIST), which are used to identify counties and county equivalents (e.g., parishes, boroughs) of the United States and its unincorporated territories (e.g., American Samoa, Guam, Northern Mariana Islands, Puerto Rico, and the US Virgin Islands). Available on EPA’s Envirofacts website at <http://www.epa.gov/envirofw/html/codes/state.html>.

⁵ EPA uses a designation category of “unclassifiable/ attainment” for areas that are monitoring attainment and for areas that do not have monitoring sites but which the EPA believes are likely attainment and does not emissions sources that are contributing to nearby violations based on the five factor analysis and other available information.

2.0 Nonattainment Area Analyses and Intended Boundary Determination

The EPA evaluated and determined the intended boundaries for each nonattainment area on a case-by-case basis considering the specific facts and circumstances unique to the area. In accordance with the CAA section 107(d), EPA intends to designate as nonattainment not only the areas with the monitoring sites that violate the 2012 annual PM_{2.5} NAAQS, but also those nearby areas with emissions sources that contribute to the violations in the violating area. As described in EPA guidance⁶, after identifying each monitoring site indicating a violation of the standard in an area, EPA analyzed those areas with emissions contributing to that violating area by considering those counties in the entire metropolitan area (e.g., Core Based Statistical Area (CBSA) or Combined Statistical Area (CSA)) in which the violating monitoring sites are located. The EPA also evaluated counties adjacent to the CBSA or CSA that have emissions sources with the potential to contribute to the violations. EPA uses the CBSA or CSA as a starting point for the contribution analysis because those areas are nearby for purposes of the PM_{2.5} NAAQS. Based upon relevant facts and circumstances in each area, the designated nonattainment area could be larger or smaller than the CBSA or CSA. EPA's analytical approach is described in section 3 of this technical support document.

3.0 Technical Analysis

In this technical analysis, EPA used the latest data and information available to EPA (and to the states and tribes through the PM_{2.5} Designations Mapping Tool⁷ and the EPA PM Designations Guidance and Data web page⁸) and/or data provided to EPA by states or tribes. This technical analysis identifies the areas with one or more monitoring sites that violate the 2012 annual PM_{2.5} standard. EPA evaluated these areas and other nearby areas with emissions sources or activities that potentially contribute to ambient fine particle concentrations at the violating monitors in the area based on the weight of evidence of the five factors recommended in EPA guidance and any other relevant information.

These five factors are:

Factor 1: Air Quality Data. The air quality data analysis involves examining available ambient PM_{2.5} air quality monitoring data at, and in the proximity of, the violating monitoring locations. This includes reviewing the design values (DV) calculated for each monitoring location in the area based on air quality data for the most recent complete 3 consecutive calendar years of quality-assured, certified air quality data in the EPA's Air Quality System (AQS). In general, EPA identifies violations using data from suitable Federal Reference Method (FRM), Federal Equivalent Method (FEM), and/or Approved Regional Method (ARM) monitors sited and

⁶ EPA issued guidance on April 16, 2013, that identified important factors that EPA intended to evaluate, in making a recommendation for area designations and nonattainment boundaries for the 2012 annual PM_{2.5} NAAQS. Available at <http://www.epa.gov/pmdesignations/2012standards/docs/april2013guidance.pdf>.

⁷ EPA's PM_{2.5} Designations Mapping Tool can be found at http://geoplatform2.epa.gov/PM_MAP/index.html.

⁸ EPA's PM Designations Guidance and Data web page can be found at <http://www.epa.gov/pmdesignations/2012standards/techenfo.htm>.

operated in accordance with 40 CFR Part 58.⁹ Procedures for using the air quality data to determine whether a violation has occurred are given in 40 CFR part 50 Appendix N, as revised by a final action published in the Federal Register on January 15, 2013 (78 FR 3086).¹⁰ In addition to reviewing data from violating monitor sites, EPA also assesses the air quality data from other monitoring locations to help ascertain the potential contribution of sources in areas nearby to the violating monitoring sites. Examples include using chemical speciation data to help characterize contributing emissions sources and the determination of nearby contributions through analyses that differentiate local and regional source contributions.

Factor 2: Emissions and emissions-related data. The emissions analysis examines identified sources of direct PM_{2.5}, the major components of direct PM_{2.5} (primary organic carbon/organic mass, elemental carbon, crustal material (and/or individual trace metal compounds)), primary nitrate and primary sulfate, and precursor gaseous pollutants (e.g., SO₂, NO_x, total VOC, and NH₃). Emissions data are generally derived from the most recent National Emissions Inventory (NEI) (i.e., 2011 NEI version 1), and are given in tons per year. In some cases, EPA may also evaluate emissions information from states, tribes, or other relevant sources that may not be reflected in the NEI. One example of “other information” could include an inventory or assessment of local/regional area sources that individually does not meet the current threshold for reporting to the NEI but collectively contributes to area PM_{2.5} concentrations. Emissions data indicate the potential for a source to contribute to observed violations, making it useful in assessing boundaries of nonattainment areas.

Factor 3: Meteorology. Evaluating meteorological data helps to determine the effect on the fate and transport of emissions contributing to PM_{2.5} concentrations and to identify areas potentially contributing to the violations at monitoring sites. The Factor 3 analysis includes assessing potential source-receptor relationships in the area identified for evaluation using summaries of air trajectories, wind speed, wind direction, and other meteorological data, as available.

Factor 4: Geography/topography. The geography/topography analysis includes examining the physical features of the land that might define the airshed and, therefore, affect the formation and distribution of PM_{2.5} over an area. Mountains or other physical features may influence the fate and transport of emissions and PM_{2.5} concentrations. Additional analyses may consider topographical features that cause local stagnation episodes via inversions, such as valley-type features that effectively “trap” air pollution, leading to periods of elevated PM_{2.5} concentrations.

Factor 5: Jurisdictional boundaries. The analysis of jurisdictional boundaries identifies the governmental planning and organizational structure of an area that may be relevant for designations purposes. These jurisdictional boundaries provide insight into how the governing air agencies conduct or might conduct air

⁹ Suitable monitors include all FEM and/or ARMs except those specific continuous FEMs/ARMs used in the monitoring agency’s network where the data are not of sufficient quality such that data are not to be compared to the NAAQS in accordance with 40 CFR part 58.10(b)(13) and approved by the EPA Regional Administrator per 40 CFR part 58.11(e).

¹⁰ As indicated in Appendix N to 40 CFR part 50, Interpretation of the National Ambient Air Quality Standards for PM_{2.5}, section 3(a) indicates “Except as otherwise provided in this appendix, all valid FRM/FEM/ARM PM_{2.5} mass concentration data produced by suitable monitors that are required to be submitted to AQS, or otherwise available to EPA, meeting the requirements of part 58 of this chapter including appendices A, C, and E shall be used in the DV (design value) calculations. Generally, EPA will only use such data if they have been certified by the reporting organization (as prescribed by § 58.15 of this chapter); however, data not certified by the reporting organization can nevertheless be used, if the deadline for certification has passed and EPA judges the data to be complete and accurate.”

quality planning and enforcement in a potential nonattainment area. Examples of jurisdictional boundaries include counties, air districts, areas of Indian country, CBSA or CSA, metropolitan planning organizations (MPOs), and existing nonattainment areas.

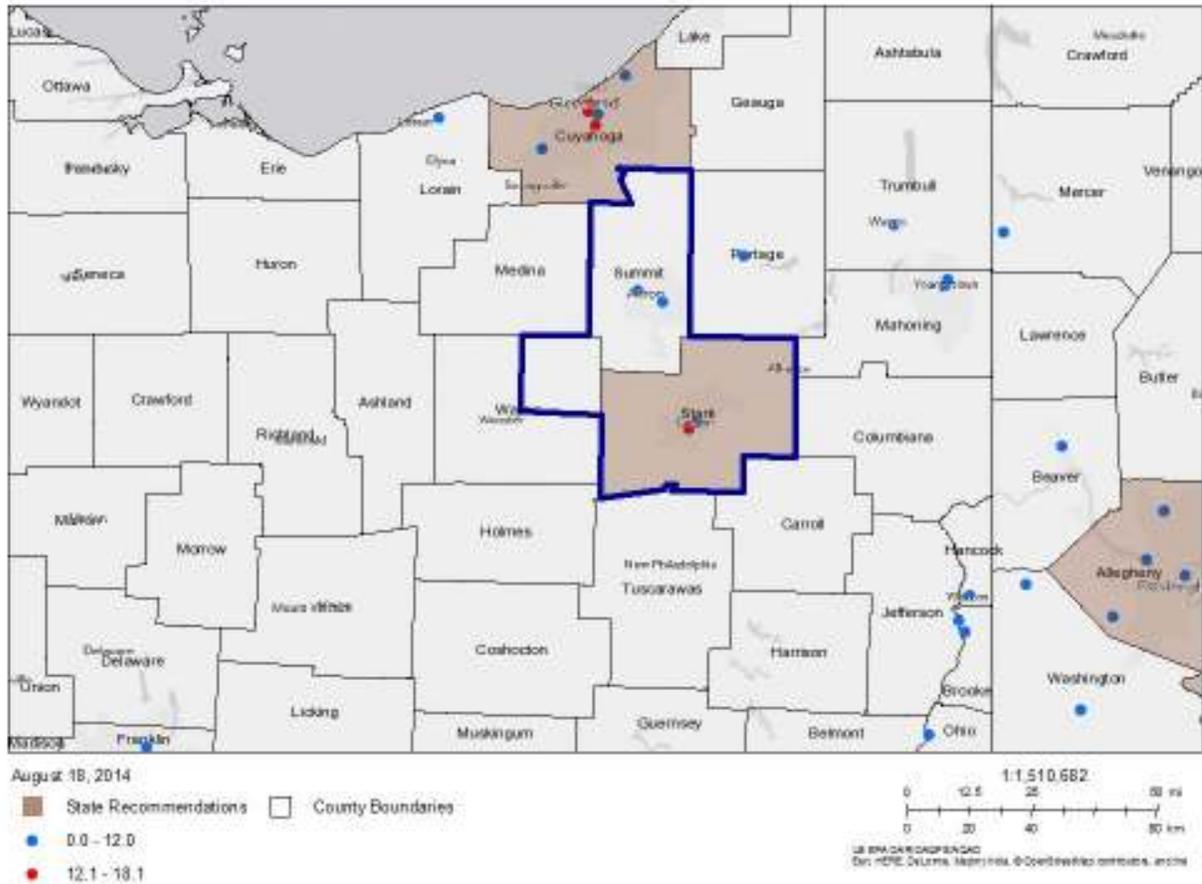
3.1 Area Background and Overview Canton-Massillon, OH Area

Figure 1a is a map of EPA's intended nonattainment boundary for the Canton-Massillon Area. The map shows the location and design values of ambient air quality monitoring locations, county boundaries and Ohio's recommended nonattainment boundary.

Portions of this area were designated nonattainment for purposes of the 1997 annual $PM_{2.5}$ NAAQS. Stark County was included within the boundary of the Canton-Massillon area for the 1997 annual $PM_{2.5}$ NAAQS. In addition, Summit County was included within the boundary of the Cleveland-Akron-Lorain Area for the 1997 annual $PM_{2.5}$ NAAQS.

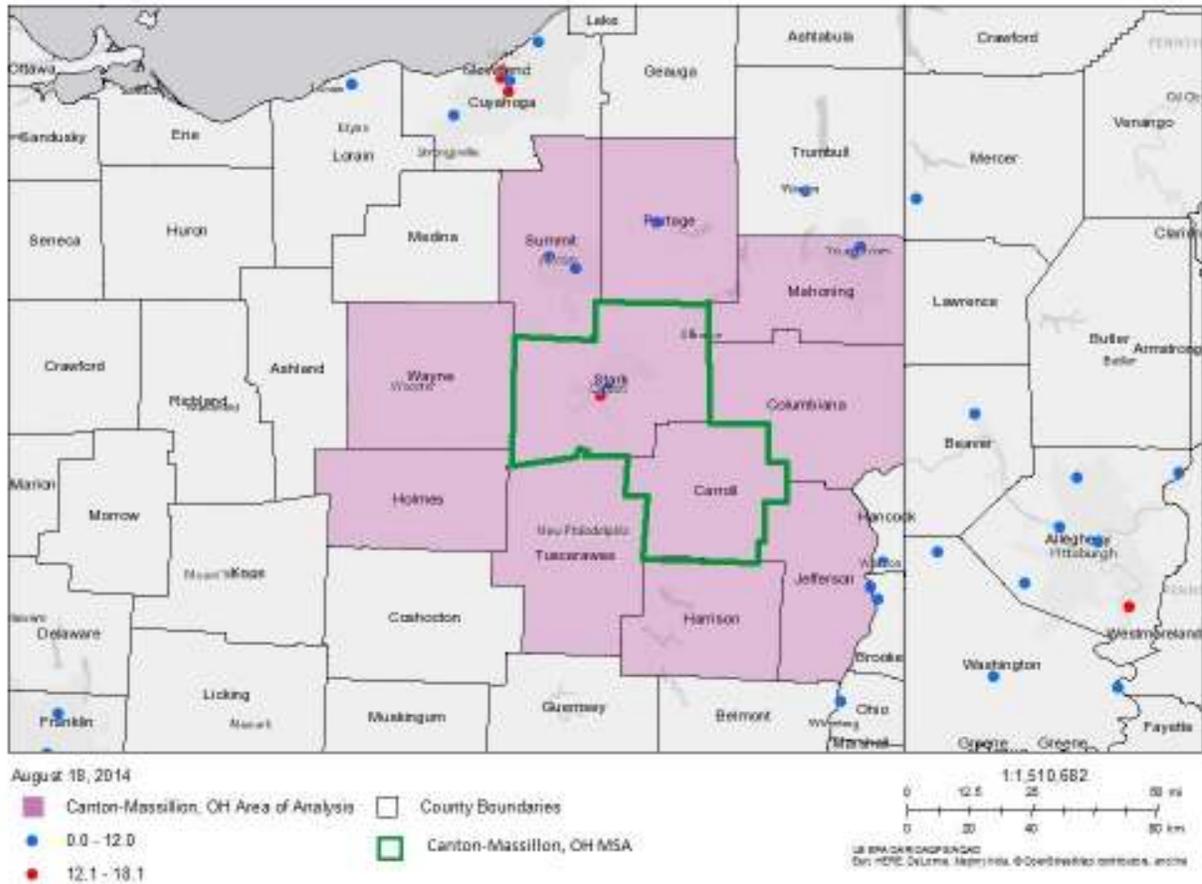
Portions of this area were also designated nonattainment for purposes of the 2006 24-hour $PM_{2.5}$ NAAQS. Stark County was included within the boundary of the Canton-Massillon area for the 2006 24-hour $PM_{2.5}$ NAAQS. In addition, Summit County was included within the boundary of the Cleveland-Akron-Lorain Area for the 2006 24-hour $PM_{2.5}$ NAAQS.

Figure 1a. EPA’s Intended Nonattainment Boundaries for the Canton-Massillon, OH Area



EPA must designate as nonattainment areas that violate the NAAQS and nearby areas that contribute to the violation in the violating area. Stark County shows a violation of the 2012 PM_{2.5} NAAQS, therefore this county is included in the nonattainment area. As shown in Figure 1b, EPA evaluated each county without a violating monitoring site located in or near the metropolitan statistical area (MSA) of the county with a violating monitoring site based on the five factors and other relevant information. The following sections describe this five factor analysis process. While the factors are presented individually, they are not independent. The five factor analysis process carefully considers their interconnections and the dependence of each factor on one or more of the others.

Figure 1b. Area of Analysis for the Canton-Massillon, OH Area



Factor 1: Air Quality Data

All data collected during the year are important when determining contributions to an annual standard such as the 2012 annual PM_{2.5} NAAQS. Compliance with an annual NAAQS is dependent upon monitor readings throughout the year, including days with monitored ambient concentrations below the level of the NAAQS. For the 2012 annual PM_{2.5} NAAQS, the annual mean is calculated as the mean of quarterly means. A high quarter can drive the mean for an entire year, which, in turn, can drive an elevated 3-year DV. Although all data are important, seasonal or episodic emissions can provide insight as to relative contributors to measured PM_{2.5} concentrations. For these reasons, for the Factor 1 air quality analysis, EPA assessed and characterized air quality at, and in the proximity of, the violating monitoring site locations first, by evaluating trends and the spatial extent of measured concentrations at monitors in the area of analysis, and then, by identifying the conditions most associated with high average concentration levels of PM_{2.5} mass in the area of analysis.

In most cases, EPA assessed air quality data on a seasonal, or quarterly, basis.¹¹ EPA also identified the spatial extent of these high PM_{2.5} concentrations. The mass and composition at the design value location represents contributions from various emission sources including local, area-wide (which may comprise nearby urban and rural areas) and regional sources. To determine the source mix (by mass) at the design value monitoring site, EPA examined the chemical composition of the monitored PM_{2.5} concentrations by pairing each violating FRM/FEM/ARM monitoring site with a collocated or nearby Chemical Speciation Network (CSN) monitoring site or sites. Then, EPA contrasted the approximated mass composition at the design value monitoring site with data collected at IMPROVE¹² and other monitoring locations whose data are representative of regional background.^{13,14} This comparison of local/area-wide chemical composition data to regional chemical composition data derives an “urban increment,” which helps differentiate the influence of more distant

¹¹ Although compliance with the annual NAAQS depends on contributions from all days of the year, examining data on a quarterly or seasonal basis can inform the relationship between the temporal variability of emissions and meteorology and the resulting PM_{2.5} mass and composition. In some areas of the country where there may be noticeable month-to-month variations in average PM_{2.5}, the quarterly averages may not adequately represent seasonal variability. In these areas, air quality data may be aggregated and presented by those months that best correspond to the local “seasons” in these areas.

¹² IMPROVE stands for Interagency Monitoring for Protected Visual Environments and is an aerosol monitoring network in mostly rural and remote areas.

¹³ The “urban increment” analysis assesses and characterizes the increase in seasonal and annual average PM_{2.5} mass and chemical constituents observed at violating monitoring site(s) relative to monitoring sites outside the area of analysis (which represent background concentrations). Developing the urban increment involves pairing a violating FRM/FEM/ARM monitor with a collocated monitor or nearby monitor with speciation data. EPA made every effort to pair these data to represent the same temporal and spatial scales. However, in some cases, the paired violating and CSN “urban” monitoring locations were separated by some distance such that the included urban CSN site(s) reflect(s) a different mixture of emissions sources, which could lead to misinterpretations. To generally account for differences in PM_{2.5} mass between the violating site and the nearby CSN site(s), EPA determined material balance of the PM_{2.5} composition at the violating site by assigning the extra measured PM_{2.5} mass to the carbon components of PM_{2.5}. Where the general urban increment approach may be misleading, or in situations where non-carbonaceous emissions are believed to be responsible for a local PM_{2.5} concentration gradient, EPA used alternative analyses to reflect the mix of urban and rural sources contributing to the measured concentrations at violating monitoring sites.

¹⁴ The urban monitors were paired with any rural sites within a 150 mile radius of an urban site to calculate spatial means of the quarterly averages of each species. If there were no rural sites within 150 miles, then the nearest rural site was used alone. That rural mean was then subtracted from the quarterly mean of the urban site to get the increment. Negative values were simply replaced with zeros.

emissions sources from the influence of closer emissions sources, thus representing the portion of the measured violation that is associated with nearby emission contributions.^{15,16,17}

PM_{2.5} Design Values and Total Mass Measurements - EPA examined ambient PM_{2.5} air quality monitoring data represented by the DVs at the violating monitoring site and at other monitors in the area of analysis. EPA calculated DVs based on air quality data for the most recent 3 consecutive calendar years of quality-assured, certified air quality data from suitable FEM/FRM/ARM monitoring sites in the EPA’s Air Quality System (AQS). For this designations analysis, EPA used data for the 2011-2013 period (i.e., the 2013 design value), which are the most recent years with fully-certified air quality data. A monitor’s DV is the metric or statistic that indicates whether that monitor attains a specified air quality standard. The 2012 annual PM_{2.5} NAAQS is met at a monitoring site when the 3-year average annual mean concentration is 12.0 micrograms per cubic meter (µg/m³) or less (e.g., 12.1 µg/m³ or greater is a violation). A DV is only valid if minimum data completeness criteria are met or when other regulatory data processing provisions are satisfied (See 40 CFR part 50 Appendix N). Table 2 identifies the current design value(s) (i.e., the 2013 DV) and the most recent two additional design values based on all monitoring sites in the area of analysis for the Canton-Massillon intended nonattainment area.¹⁸ Where a county has more than one monitoring location, the county design value is indicated in red type.

Table 2. Air Quality Data collected at Regulatory Monitors (all DV levels in µg/m³)^a

County, State	Monitor Site ID	State Rec NA?	09-11 DV	10-12 DV	11-13 DV
Carroll, OH	N/A	No		No monitor	
Columbiana, OH	N/A	No		No monitor	
Harrison, OH	N/A	No		No monitor	
Holmes, OH	N/A	No		No monitor	

¹⁵ In most, but not all, cases, the violating design value monitoring site is located in an urban area. Where the violating monitor is not located in an urban area, the “urban increment” represents the difference between local and other nearby emission sources in the vicinity of the violating monitoring location and more regional sources.

¹⁶ Hand, et. al. Spatial and Seasonal Patterns and Temporal Variability of Haze and its Constituents in the United States: Report V, June 2011. Chapter 7 – Urban Excess in PM_{2.5} Speciated Aerosol Concentrations, <http://vista.cira.colostate.edu/improve/Publications/Reports/2011/PDF/Chapter7.pdf>

¹⁷ US EPA, Office of Air Quality Planning and Standards, December 2004. (2004) Area Designations for 1997 Fine Particle (PM_{2.5}) Standards, Technical Support Document for State and Tribal Air Quality Fine Particle (PM_{2.5}) Designations, Chapter 3, Urban Excess Methodology. Available at www.epa.gov/pmdesignations/1997standards/documents/final/TSD/Ch3.pdf

¹⁸ In certain circumstances, one or more monitoring locations within a monitoring network may not meet the network technical requirements set forth in 40 CFR 58.11(e), which states, “State and local governments must assess data from Class III PM_{2.5} FEM and ARM monitors operated within their network using the performance criteria described in table C-4 to subpart C of part 53 of this chapter, for cases where the data are identified as not of sufficient comparability to a collocated FRM, and the monitoring agency requests that the FEM or ARM data should not be used in comparison to the NAAQS. These assessments are required in the monitoring agency’s annual monitoring network plan described in §58.10(b) for cases where the FEM or ARM is identified as not of sufficient comparability to a collocated FRM....”

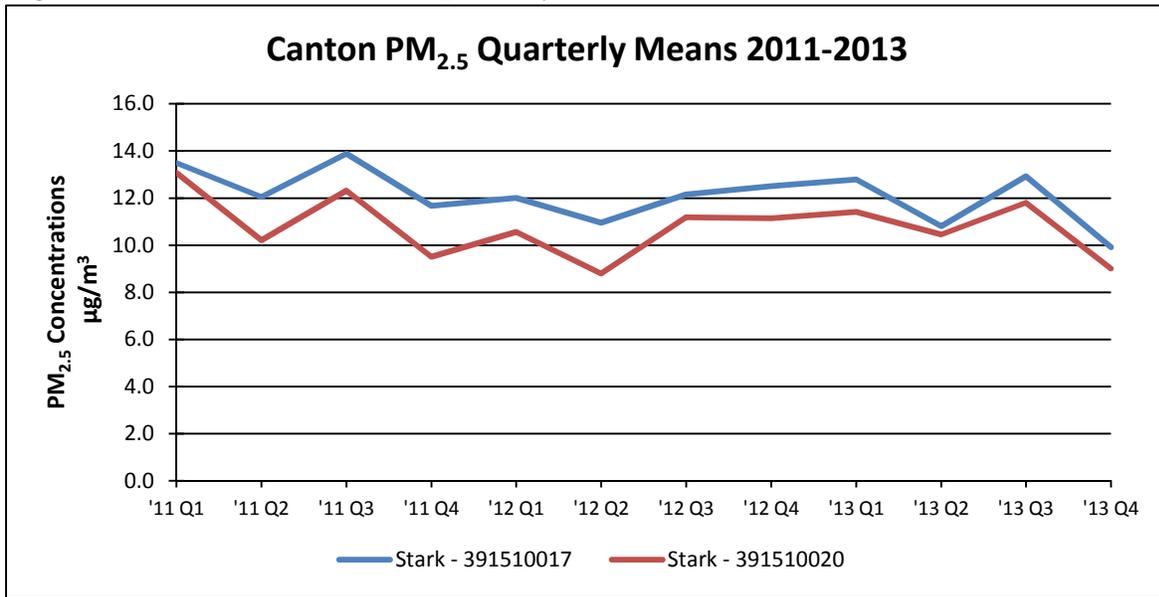
County, State	Monitor Site ID	State Rec NA?	09-11 DV	10-12 DV	11-13 DV
Jefferson, OH	390810017	No	12.5	12.2	11.6
Jefferson, OH	390811001	No	11.8	11.4	10.8
Mahoning, OH	390990005	No	11.4	11.2	10.7
Mahoning, OH	390990014	No	11.8	11.3	10.4
Portage, OH	391330002	No	10.9	10.3	9.5
Stark, OH	391510017	Yes	13.4	13.0	12.1
Stark, OH	391510020	Yes	12.3	11.8	10.8
Summit, OH	391530017	No	12.6	12.0	11.0
Summit, OH	391530023	No	11.7	11.2	10.4
Tuscarawas, OH	N/A	No	No monitor		
Wayne, OH	N/A	No	No monitor		

^aWhere a county has more than one monitoring location, the county design value is indicated in red type.

The Figure 1 map, shown previously, identifies the Canton-Massillon intended nonattainment area, the MSA boundary and monitoring locations with 2011-2013 violating DVs. As indicated on the map, there is one violating monitor located in the city of Canton in Stark County.

Seasonal variation can highlight those conditions most associated with high average concentration levels of PM_{2.5}. Figure 2 shows quarterly mean PM_{2.5} concentrations for the most recent 3-year period for the highest DV monitoring sites in each county within the area of analysis, as well as an additional non-violating monitoring site in the Canton-Massillon metropolitan statistical area (MSA). This graphical representation is particularly relevant when assessing air quality data for an annual standard, such as the 2012 annual PM_{2.5} NAAQS, because, as previously stated, the annual mean is calculated as the mean of quarterly means and a high quarter can drive the mean for an entire year, which, in turn, can drive an elevated 3-year DV.

Figure 2. Canton-Massillon PM_{2.5} Quarterly Means for 2011-2013



For the Canton-Massillon MSA monitors, quarterly values across the 3-year period vary by 1-3 µg/m³ at each site, with higher concentrations typically occurring in Q1 and Q3. Annual peaks most often occur in Q3, although one annual peak was recorded in Q1 and one in Q4. This suggests that these quarters should be considered more closely when evaluating chemical constituent and urban increment data. ...

PM_{2.5} Composition Measurements - To assess potential emissions contributions for each violating monitoring location, the EPA determined the various chemical species comprising total PM_{2.5} to identify the chemical constituents over the analysis area, which can provide insight into the types of emission sources impacting the monitored concentration. To best describe the PM_{2.5} at the violating monitoring location, EPA first adjusted the chemical speciation measurement data from a monitoring location at or near the violating FRM monitoring site using the SANDWICH approach to account for the amount of PM_{2.5} mass constituents retained in the FRM

measurement.^{19,20,21,22} In particular, this approach accounts for losses in fine particle nitrate and increases in sulfate mass associated with particle bound water. Figure 3a illustrates the fraction of each PM_{2.5} chemical constituent at monitoring site 391510017 in Stark County based on annual averages for the years 2010-2012.

Figure 3a. Canton-Massillon Annual Average PM_{2.5} Chemical Constituents (2010-2012)

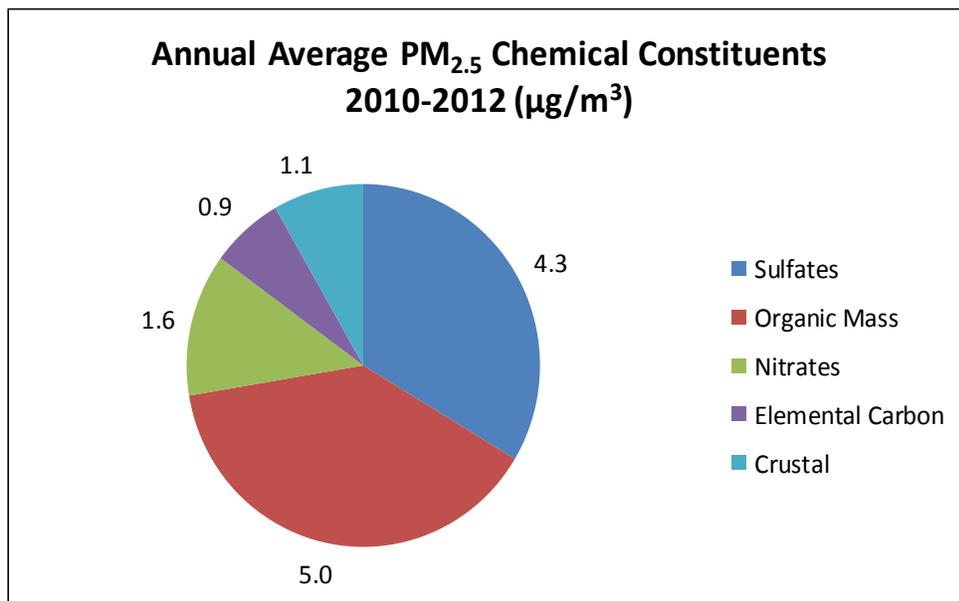


Figure 3b shows annual and quarterly chemical composition profiles and illustrates any seasonal or episodic contributors to PM_{2.5} mass. This “increment analysis,” combined with the other factor analyses, can provide

¹⁹ SANDWICH stands for measured Sulfate, Adjusted Nitrate, Derived Water, Inferred Carbonaceous mass Hybrid Material Balance Approach.” The SANDWICH adjustment uses an FRM mass construction methodology that results in reduced nitrates (relative to the amount measured by routine speciation networks), higher mass associated with sulfates (reflecting water included in gravimetric FRM measurements) and a measure of organic carbonaceous mass derived from the difference between measured PM_{2.5} and its non-carbon components. This characterization of PM_{2.5} mass also reflects crustal material and other minor constituents. The resulting characterization provides a complete mass closure for the measured FRM PM_{2.5} mass, which can be different than the data provided directly by the speciation measurements from the CSN network.

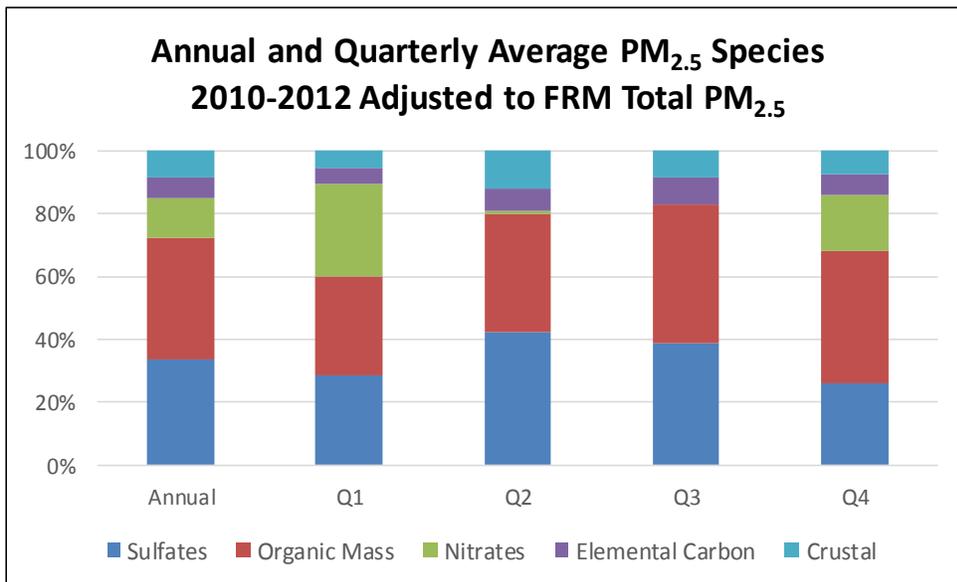
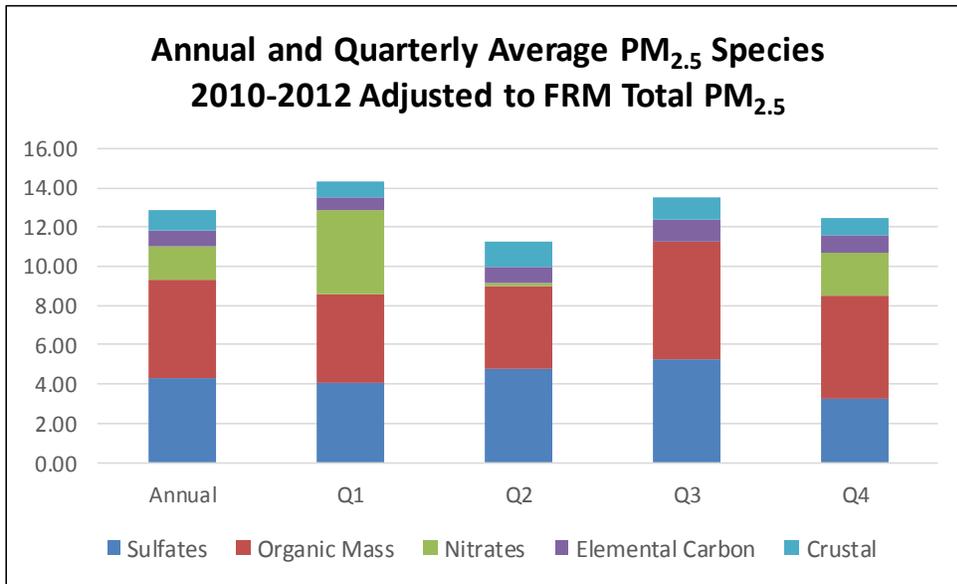
²⁰ Frank, N. H., SANDWICH Material Balance Approach for PM_{2.5} Data Analysis, National Air Monitoring Conference, Las Vegas, Nevada, November 6-9, 2006. <http://www.epa.gov/ttn/amtic/files/2006conference/frank.pdf>.

²¹ Frank, N. H., The Chemical Composition of PM_{2.5} to support PM Implementation, EPA State /Local/Tribal Training Workshop: PM_{2.5} Final Rule Implementation and 2006 PM_{2.5} Designation Process, Chicago IL, June 20-21, 2007, http://www.epa.gov/ttn/naaqs/pm/presents/pm2.5_chemical_composition.pdf.

²² Frank, N. H. *Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities*. J. Air & Waste Manage. Assoc. 2006 56:500–511.

additional insight as to which sources or factors may contribute at a greater level. Simply stated, this analysis can help identify nearby sources of emissions that contribute to the violation at the violating monitoring site.

Figure 3b. Canton-Massillon Area Annual and Quarterly Average PM_{2.5} Species (2010-2012)^a

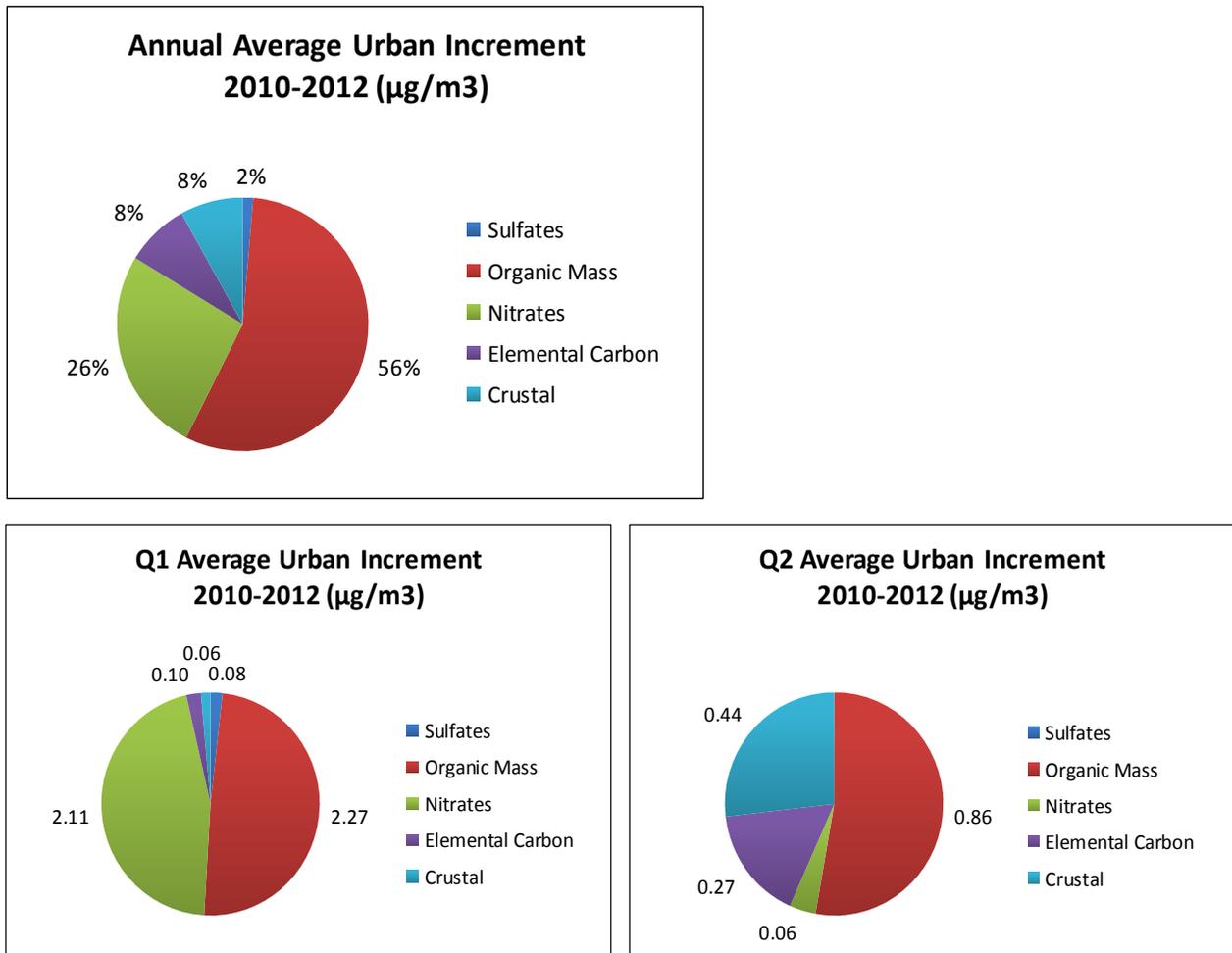


^aAdjusted to FRM Total PM_{2.5} indicates that the speciation profile and total mass depicted in this figure are the result of the SANDWICH calculations from speciation measurements for the particular PM_{2.5} monitoring site.

Figure 3b shows that sulfate and organic mass are the predominant species, with an exception in Q1 where nitrates comprise a fraction comparable to sulfates and organic mass. Crustal and elemental carbon are relatively small components, contributing from 6-12% and 5-7%, respectively. Figure 3b suggests that sulfate, organic mass and nitrate sources have the highest impact on the monitored values in the Canton-Massillon area.

EPA assessed seasonal and annual average $PM_{2.5}$ constituents at monitoring sites within the area relative to monitoring sites outside of the analysis area to account for the difference between regional background concentrations of $PM_{2.5}$, and concentrations of $PM_{2.5}$ in the area of analysis, also known as the “urban increment.” This analysis differentiates between the influences of emissions from sources in nearby areas and in more distant areas on the violating monitor. Estimating the urban increment in the area helps to illuminate the amount and type of particles at the violating monitor that are most likely to be the result of sources of emissions in nearby areas, as opposed to impacts of more distant or regional sources of emissions. Figure 4a includes pie charts showing the annual and quarterly chemical mass constituents of the urban increment. The quarterly pie charts correspond to the high-concentration quarters identified in Figure 2. Evaluating these high-concentration quarters can help identify composition of $PM_{2.5}$ during these times. Note that in these charts, sulfates and nitrates have been adjusted to represent their mass in measured $PM_{2.5}$.

Figure 4a. Canton-Massillon Area Urban Increment Analysis for 2010-2012.



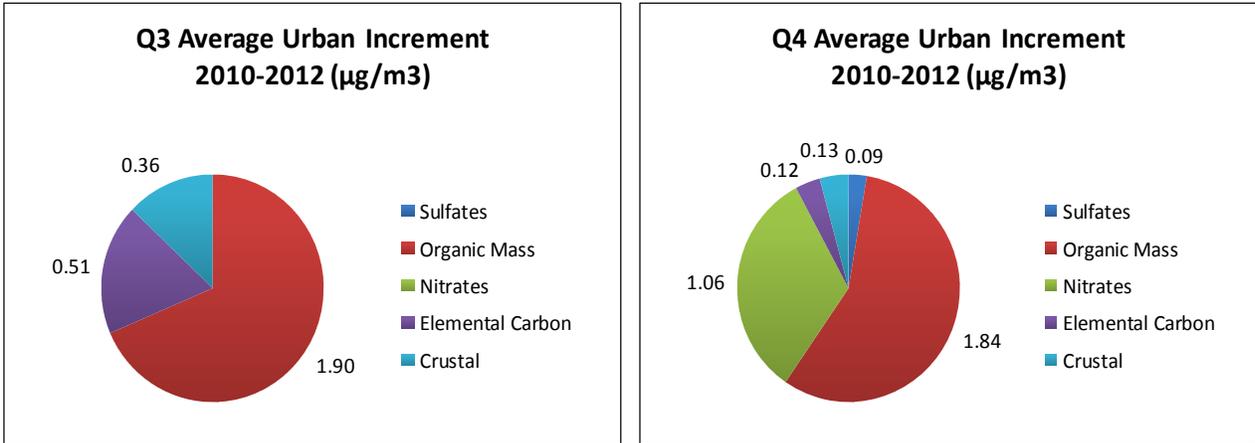
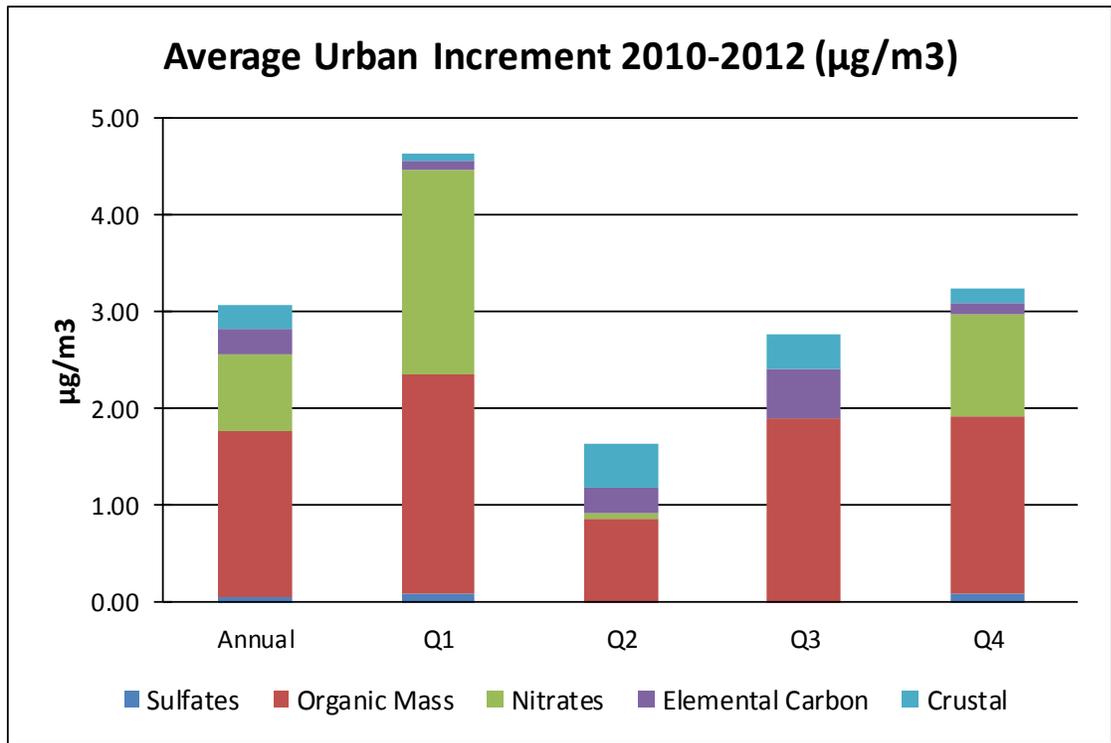


Figure 4b. Canton-Massillon Area Average Urban Increment Analysis for 2010-2012.



As shown in Figure 2, Stark County has one monitoring site with a DV exceeding the NAAQS. Stark County ambient $\text{PM}_{2.5}$ concentrations are fairly consistent across the year, with moderate seasonal peaks in Q1 and Q3, although one annual high was recorded in Q4. This suggests that particular attention should be given to urban increment information for Q1 and Q2, although data for Q4 also needs to be evaluated.

In reviewing the urban increment analysis for the Canton-Massillon DV monitor, organic mass consistently represents the largest component. Sulfate appears to consistently have small urban contribution, although conversely large regional contribution. Nitrate is the second highest urban increment component for Q1 and

Q4, but is not a factor in Q3, during which crustal and elemental carbon both comprise a higher percentage. This analysis points to contribution from local nitrate and direct PM_{2.5} sources nearby the violating monitor and contribution from regional sulfate and nitrate sources.

Factor 2: Emissions and emissions-related data

In this designations process, for each area with a violating monitoring site, EPA evaluated the emissions data from nearby areas using emissions related data for the relevant counties to assess each county's potential contribution to PM_{2.5} concentrations at the violating monitoring site or monitoring sites in the area under evaluation. Similar to the air quality analysis, these data were examined on a seasonal basis. However, seasonal emission trends are not significantly different, and the seasonal patterns are similar for all major emitted pollutants; therefore EPA is only analyzing annual emissions data. (Although nitrate is much higher in the cooler months, NO_x emissions have similar importance all year due to their role in fostering the photochemistry that causes secondary particulate matter.)

EPA examined emissions of identified sources or source categories of direct PM_{2.5}, the major components of direct PM_{2.5} (organic mass, elemental carbon, crustal material (and/or individual trace metal compounds)), primary nitrate and primary sulfate, and precursor gaseous pollutants (i.e., SO₂, NO_x, total VOC, and NH₃). EPA also considered the distance of those sources of emissions from the violating monitoring site. While direct PM_{2.5} emissions and its major carbonaceous components are generally associated with sources near violating PM_{2.5} monitoring sites, the gaseous precursors tend to have a more regional influence (although the EPA is mindful of the potential for local NO_x and VOC emissions contributions to PM_{2.5} from mobile and stationary sources) and transport from neighboring areas can contribute to higher PM_{2.5} levels at the violating monitoring sites.

Emissions Data

For this factor, EPA reviewed data from the 2011 National Emissions Inventory (NEI) version 1 (see <http://www.epa.gov/ttn/chief/net/2011inventory.html>). For each county in the area of analysis, EPA examined the magnitude of county-level emissions reported in the NEI. These county-level emissions represent the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, nonroad mobile, on-road mobile, and fires. EPA also looked at the geographic distribution of major point sources of the relevant pollutants.²³ Significant emissions levels from sources in a nearby area indicate the potential for the area to contribute to monitored violations.

To further analyze area emissions data, EPA also developed a summary of direct PM_{2.5}, components of direct PM_{2.5}, and precursor pollutants, which is available at http://www.epa.gov/pmdesignations/2012standards/docs/nei2011v1county_nei2011v1point_nei2008v3_county.xlsx.

²³ For purposes of this designations effort, "major" point sources are those whose sum of PM precursor emissions (PM_{2.5} + NO_x + SO₂ + VOC + NH₃) are greater than 500 tons per year based on NEI 2011v1.

When considered with the urban increment analysis in Factor 1, evaluating the components of direct PM_{2.5} and precursor gases can help identify specific sources or source types contributing to elevated concentrations at violating monitoring sites and thus assist in identifying appropriate area boundaries. In general, directly emitted particulate organic carbon (POC) and VOCs²⁴ contribute to PM_{2.5} organic mass (OM); directly emitted EC contributes to PM_{2.5} EC; NO_x, NH₃ and directly emitted nitrate contribute to PM_{2.5} nitrate mass; SO₂, NH₃ and directly emitted sulfate contribute to PM_{2.5} sulfate mass; and directly emitted crustal material and metal oxides contribute to PM_{2.5} crustal matter.^{25,26} EPA believes that the quantities of those nearby emissions as potential contributors to the PM_{2.5} violating monitors are somewhat proportional to the PM_{2.5} chemical constituents in the estimated urban increment. Thus, directly emitted POC is more important per ton than SO₂, partially because POC emissions are already PM_{2.5} whereas SO₂ must convert to PM_{2.5} and not all of the emitted SO₂ undergoes this conversion.

Table 3a provides a county-level emissions summary (i.e., the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, nonroad mobile, on-road mobile, and fires) of directly emitted PM_{2.5} and precursor species for the county with the violating monitoring site and nearby counties considered for inclusion in the Canton-Massillon area. Table 3b summarizes the directly emitted components of PM_{2.5} for the same counties in the area of analysis for the Canton-Massillon area. This information will be considered in conjunction with the urban increment composition information previously shown in Figures 4a and 4b.

Table 3a. County-Level Emissions of Directly Emitted PM_{2.5} and Precursors (tons/year)

County, State	Total NO _x	Total SO ₂	Total Direct PM _{2.5}	Total NH ₃	Total VOC	Total
Jefferson, OH	12,593	29,761	10,072	234	2,522	55,181
Summit, OH	16,925	4,310	1,760	495	13,110	36,601
Wayne, OH	7,323	18,028	2,080	3,868	4,637	35,937
Stark, OH	14,466	566	2,471	2,159	12,424	32,085
Mahoning OH	9,712	1,481	1,031	738	7,430	20,392
Portage, OH	6,428	170	858	473	5,604	13,533
Tuscarawas, OH	4,399	2,482	819	1,138	4,176	13,014
Columbiana, OH	4,160	173	677	2,024	3,963	10,996
Holmes, OH	1,601	100	656	2,261	2,199	6,817
Carroll, OH	1,649	70	428	436	1,562	4,146
Harrison, OH	731	99	495	220	1,184	2,730

²⁴ As previously mentioned, nearby VOCs are presumed to be a less important contributor to PM_{2.5} OM than POC.

²⁵ See, Seinfeld J. H. and Pandis S. N. (2006) *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, 2nd edition, J. Wiley, New York. See also, Seinfeld J. H. and Pandis S. N. (1998) *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, 1st edition, J. Wiley, New York.

²⁶ USEPA Report (2004), The Particle Pollution Report: Current Understanding of Air Quality and Emissions through 2003, found at: <http://www.epa.gov/airtrends/aqtrnd04/pm.html>.

Table 3b. County-Level Emissions for Components of Directly Emitted PM_{2.5} (tons/year)²⁷

County, State	POM	EC	PSO ₄	PNO ₃	Pcrustal	Residual	Total Direct PM _{2.5}
Jefferson, OH	598	412	780	6	3,721	4,555	10,072
Stark, OH	738	375	124	6	616	612	2,471
Wayne, OH	418	186	106	3	598	769	2,080
Summit, OH	857	451	36	3	179	234	1,760
Mahoning OH	428	254	26	3	135	184	1,031
Portage, OH	390	201	15	2	103	147	858
Tuscarawas, OH	387	161	24	5	97	145	819
Columbiana, OH	328	124	12	2	88	123	677
Holmes, OH	400	67	7	1	84	96	656
Harrison, OH	380	49	4	1	20	41	495
Carroll, OH	250	47	9	2	35	86	428

Table 3b breaks down the direct PM_{2.5} emissions value from Table 3a into its components. These data will also be compared with the previously presented Urban Increment composition.

Using the previously described relationship between directly emitted and precursor gases and the measured mass to evaluate data presented in Tables 3a and 3b, EPA identified the following components warranting additional review: POM, NO_x, SO₂, EC, and Pcrustal. EPA then looked at the contribution of these constituents of interest from each of the counties included in the area of analysis, as shown in Tables 4a-e.

Table 4a. County-Level Primary Organic Mass Emissions (tons/year)

County, State	POM	Percent	Cumulative %
Summit, OH	857	17%	17%
Stark, OH	738	14%	31%
Jefferson, OH	598	12%	42%
Mahoning OH	428	8%	51%
Wayne, OH	418	8%	59%
Holmes, OH	400	8%	66%
Portage, OH	390	8%	74%
Tuscarawas, OH	387	7%	81%
Harrison, OH	380	7%	89%
Columbiana, OH	328	6%	95%
Carroll, OH	250	5%	100%

²⁷ Data are based on the 2011 and 2018 Emissions Modeling Platform Data Files and Summaries (<ftp://ftp.epa.gov/EmisInventory/2011v6/v1platform>) available at: <http://www.epa.gov/ttn/chief/emch/index.html#2011> (accessed 02/26/14).

Table 4b. County-Level NO_x Emissions

County, State	NO_x	Percent	Cumulative %
Summit, OH	16,925	21%	21%
Stark, OH	14,466	18%	39%
Jefferson, OH	12,593	16%	55%
Mahoning OH	9,712	12%	67%
Wayne, OH	7,323	9%	76%
Portage, OH	6,428	8%	84%
Tuscarawas, OH	4,399	5%	90%
Columbiana, OH	4,160	5%	95%
Carroll, OH	1,649	2%	97%
Holmes, OH	1,601	2%	99%
Harrison, OH	731	1%	100%

Table 4c. County-Level SO₂ Emissions

County, State	SO₂	Percent	Cumulative %
Jefferson, OH	29,761	52%	52%
Wayne, OH	18,028	31%	83%
Summit, OH	4,310	8%	91%
Tuscarawas, OH	2,482	4%	95%
Mahoning OH	1,481	3%	98%
Stark, OH	566	1%	99%
Columbiana, OH	173	0%	99%
Portage, OH	170	0%	100%
Holmes, OH	100	0%	100%
Harrison, OH	99	0%	100%
Carroll, OH	70	0%	100%

Table 4d. County-Level Primary Elemental Carbon Emissions

County, State	EC	Percent	Cumulative %
Summit, OH	451	19%	19%
Jefferson, OH	412	18%	37%
Stark, OH	375	16%	53%
Mahoning OH	254	11%	64%
Portage, OH	201	9%	73%
Wayne, OH	186	8%	81%
Tuscarawas, OH	161	7%	88%
Columbiana, OH	124	5%	93%
Holmes, OH	67	3%	96%
Harrison, OH	49	2%	98%
Carroll, OH	47	2%	100%

Table 4e. County-Level Primary Crustal Emissions

County, State	Perustal	Percent	Cumulative %
Jefferson, OH	3,721	66%	66%
Stark, OH	616	11%	76%
Wayne, OH	598	11%	87%
Summit, OH	179	3%	90%
Mahoning OH	135	2%	92%
Portage, OH	103	2%	94%
Tuscarawas, OH	97	2%	96%
Columbiana, OH	88	2%	98%
Holmes, OH	84	1%	99%
Carroll, OH	35	1%	100%
Harrison, OH	20	0%	100%

In addition to reviewing county-wide emissions of PM_{2.5} and PM_{2.5} precursors in the area of analysis, EPA also reviewed emissions from major point sources located in the area of analysis. The magnitude and location of these sources can help inform nonattainment boundaries. Table 5 provides facility-level emissions of direct PM_{2.5}, components of direct PM_{2.5}, and precursor pollutants (given in tons per year) from major point sources located in the area of analysis for the Canton-Massillon area. Table 5 also shows the distance from the facility to the DV monitor.

Table 5. NEI 2011 v1 Point Source Emissions (tons/year)

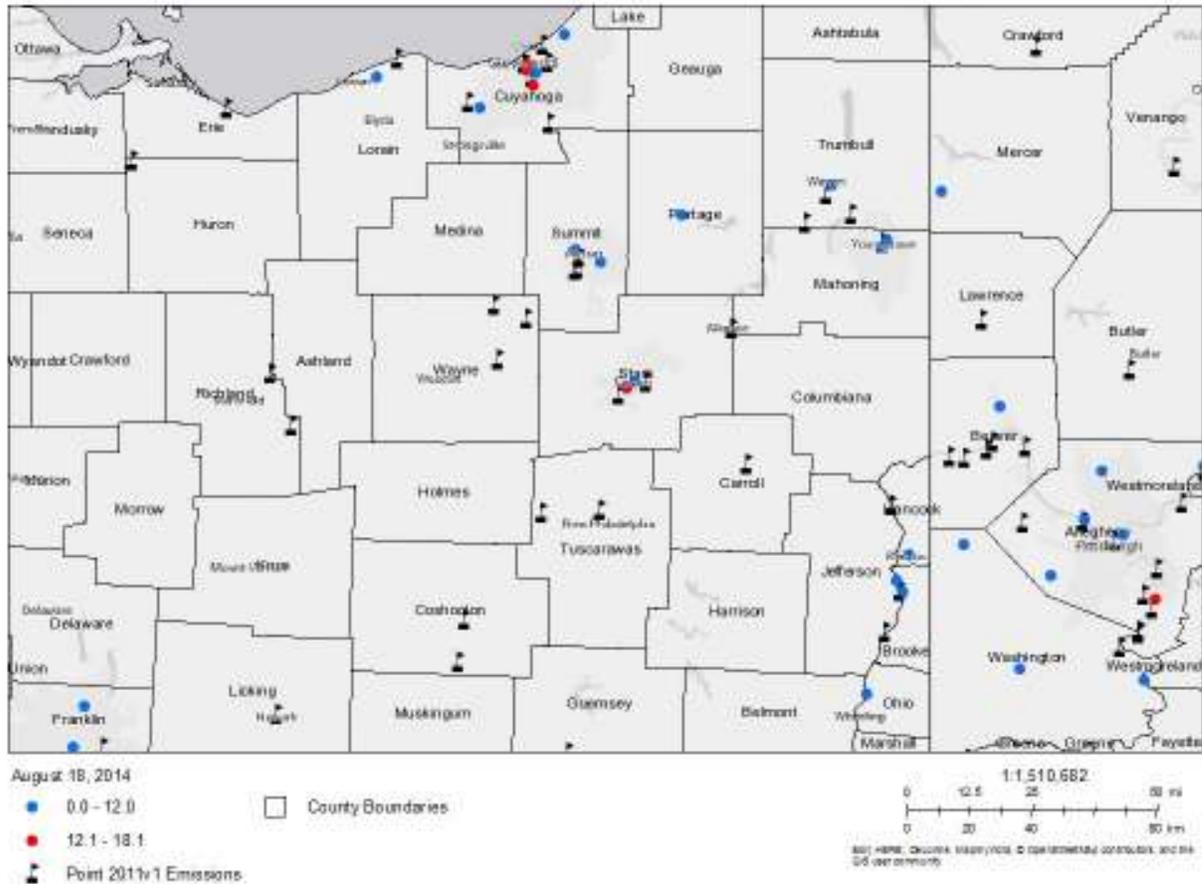
County, State	Facility Name (Facility ID)	Distance to Monitor (miles)	NEI 2011 v1 Emissions - Tons/Year					
			NH ₃	NO _x	PM _{2.5}	SO ₂	VOC	Total
Carroll, OH	Tennessee Gas Pipeline- Station 214 (0210000046)	22		662	4	0	23	689
Jefferson, OH	Cardinal Power Plant (Cardinal Operating Company) (0641050002)	54	3	2,250	616	25,122	103	28,094
Jefferson, OH	W. H. Sammis Plant (0641160017)	44	1	7,544	6,916	4,153	141	18,756
Mahoning, OH	Youngstown Thermal (0250110024)	44	0	123	19	1,063	1	1,206
Stark, OH	Alliance Casting Co. LLC (1576010014)	18		614	216	3	33	865
Stark, OH	Republic Engineered Products, Inc. (1576050694)	3	2	224	174	63	66	529
Stark, OH	Marathon Petroleum Company LP - Canton Refinery (1576002006)	1	8	285	188	93	224	798
Summit, OH	Cargill, Incorporated - Salt Division (Akron, OH) (1677010027)	19	0	140	18	1,516	1	1,676
Summit, OH	Emerald Performance Materials, LLC (1677010029)	20	0	115	1	869	10	996
Summit, OH	City of Akron Steam Generating (1677010757)	21	0	254	44	1,729	2	2,028
Tuscarawas, OH	Dover Municipal Light Plant (0679010146)	19	0	278	27	1,396	1	1,702
Tuscarawas, OH	The Belden Brick Company (0679000118)	23		39	46	957	4	1,045
Wayne, OH	Department of Public Utilities, City of Orrville, Ohio (0285010188)	20	0	1,902	745	13,038	5	15,690
Wayne, OH	Morton Salt, Inc. (0285020059)	24	0	195	50	4,434	2	4,681
Wayne, OH	East Ohio Gas - Chippewa Station (0285000366)	18		654	13	0	23	690

Figure 5 shows the major point source emissions (from the 2011 NEI in tons per year) in the area of analysis for the Canton-Massillon area and the relative distances of these sources from the violating monitoring location, as depicted by red dot in Stark County. The actual distance from the point sources to the DV monitoring location is presented in Table 5. The distance from the violating monitoring location is particularly important for directly emitted PM_{2.5}. The influence of directly emitted PM_{2.5} on ambient PM_{2.5} diminishes more than that of gaseous precursors as a function of distance.²⁸

As indicated in Table 5, there are 15 major point sources located within the area of analysis – all within approximately 50 miles of the violating monitor. Nine of these sources are in the intended nonattainment area.

²⁸ Baker, K. R. and K. M. Foley. *A nonlinear regression model estimating single source concentrations of primary and secondarily formed PM_{2.5}*. Atmospheric Environment. 45 (2011) 3758-3767.

Figure 5. Major Point Source Emissions in the Area of Analysis for the Canton-Massillon Area.



In summary, EPA’s evaluation of county-level emissions from Table 3a shows that Jefferson, Summit, Wayne, Stark and Mahoning Counties account for 78% of the total emissions in the area of analysis. However, after evaluating meteorology, discussed in greater detail below under Factor 3, it becomes apparent that emissions from sources located east of the monitor are unlikely to have a meaningful impact on the monitored violation. Therefore, while Jefferson and Mahoning Counties have significant emissions, these emissions are unlikely to have a meaningful impact on the monitored violation recorded in Stark County. Columbiana County is also located east of Stark County, between Mahoning and Jefferson Counties and is therefore also unlikely to meaningfully contribute to the monitored violation in Stark County.

Consideration of emissions in the eight other counties shows that Stark is responsible for 22% of emissions and 26% of direct PM_{2.5} emissions. Together, Stark, Summit, and Wayne Counties are responsible for 72% of emissions and 66% of PM_{2.5} emissions. In addition, when considering these eight counties, Stark County contributes 19%, 27%, 2%, 24% and 36% to the POM, NO_x, SO₂, EC, and Pcrustal components, respectively, while Stark, Summit, and Wayne Counties together contribute 53%, 72%, 89%, 66% and 80% to the POM,

NO_x, SO₂, EC, and Perustal components, respectively. Emissions in Portage, Tuscarawas, Holmes, Harrison and Carroll Counties are relatively low compared to the other counties in the area of analysis. Of these counties, Portage's emissions comprise 9% of the total emissions in these eight other counties.

Of the major point sources listed in Table 5 that are located in the eight counties not excluded for meteorological reasons, the largest point source is in Wayne County. In addition, the two largest point sources in Wayne County account for 70% of the SO₂ emissions in the eight counties. Further, Wayne County is directly west of Stark County with point sources located only 18-24 miles from the violating monitor. Given the strong westerly component shown in the wind roses in Figure 8, below, these point source emissions would be expected to contribute to PM_{2.5} concentrations recorded at the Stark County monitor. Taken together, 89% of the total emissions from major sources in these eight counties come from facilities in Stark County, Summit County, and Wayne County. While Jefferson County has the two largest sources in the full area of analysis, this county has historically been addressed as part of the Steubenville area and, as previously noted, meteorological considerations indicate that emissions from Jefferson County are unlikely to contribute to the monitored violation in Stark County, particularly with the point source being located near the eastern border of the county, along the Ohio River.

Population density and degree of urbanization

In this part of the factor analysis, EPA evaluated the population and vehicle use characteristics and trends of the area as indicators of the probable location and magnitude of non-point source emissions. Rapid population growth in a county on the urban perimeter signifies increasing integration with the core urban area, and indicates that it may be appropriate to include the county associated with area source and mobile source emissions as part of the nonattainment area. Table 6 shows the 2000 and 2010 population, population growth since 2000, and population density for each county in the area.

Table 6. Population Growth and Population Density.

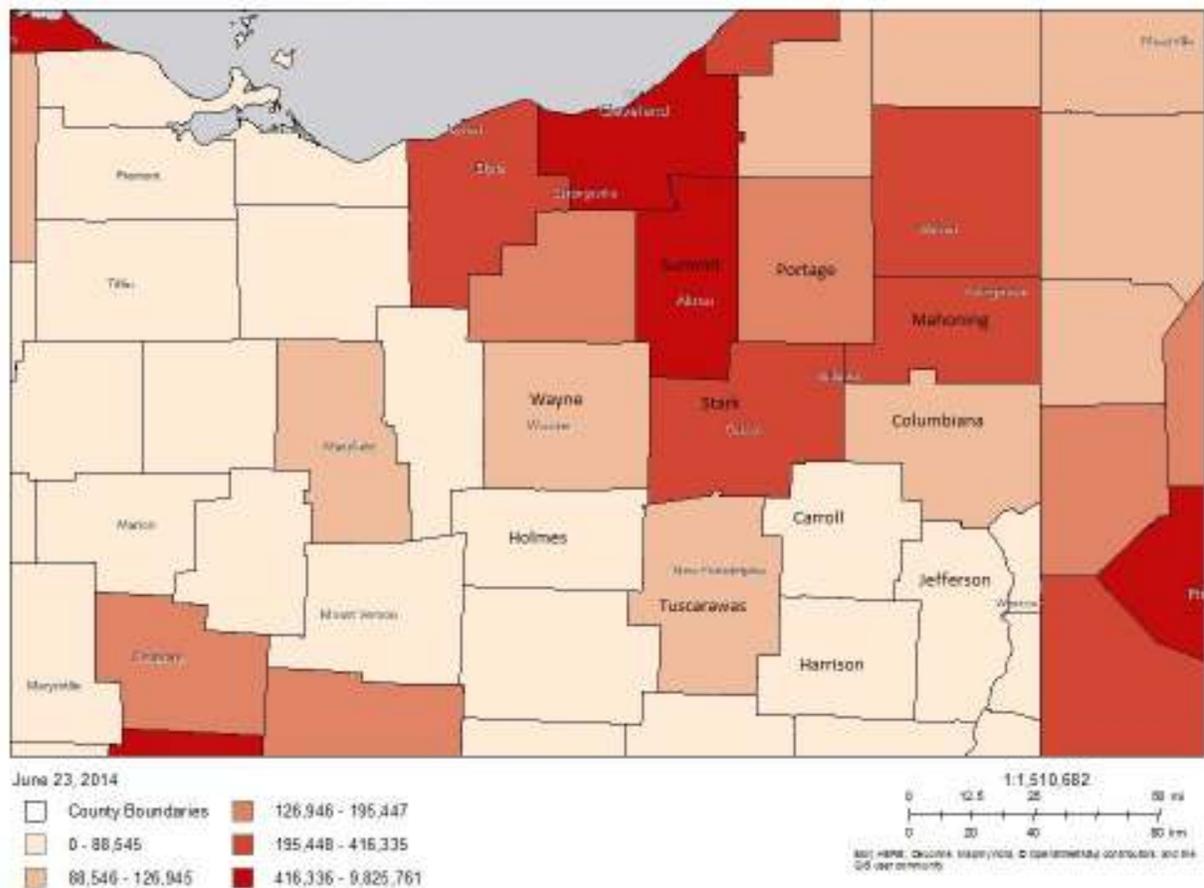
County, State	Population 2000	Population 2010	% Change from 2000	Land Area (Sq. Miles)	Population Density (per Sq. Mile)	%	Cumulative %	% Urban ^a
Summit, OH	542,899	541,652	-0.2%	413	1,312	30%	30%	47%
Stark, OH	378,098	375,417	-0.7%	576	652	21%	51%	22%
Mahoning OH	257,555	238,339	-7.5%	415	574	13%	65%	23%
Portage, OH	152,061	161,403	6.1%	492	328	9%	74%	13%
Wayne, OH	111,564	114,480	2.6%	555	206	6%	80%	5%
Columbiana, OH	112,075	107,820	-3.8%	532	202	6%	86%	6%
Tuscarawas, OH	90,914	92,565	1.8%	568	163	5%	91%	5%
Jefferson, OH	73,894	69,593	-5.8%	410	170	4%	95%	4%
Holmes, OH	38,943	42,448	9.0%	423	100	2%	98%	<1%
Carroll, OH	28,836	28,800	-0.1%	395	73	2%	99%	1%
Harrison, OH	15,856	15,857	0.0%	404	39	1%	100%	<1%
Total	1,802,695	1,788,374						

Source: U.S. Census Bureau population estimates for 2000 and 2010

^a Source: Ohio Department of Development, Ohio County Profiles: http://development.ohio.gov/reports/reports_countytrends_map.htm

When considering the entire area of analysis, Summit County has by far the greatest population, population density, and percent urban. Considering 2010 population and population density, Stark County is next most populous and population-dense county, followed by Mahoning, Portage, Wayne and Columbiana counties. When setting aside Mahoning, Columbiana, and Jefferson counties – which are unlikely to contribute to violations given the relation between available meteorological data – Summit and Stark counties together contain 67% of the total population of these counties. Population and population density are significantly lower in the other six counties.

Figure 6. 2010 County-Level Population in the Area of Analysis for the Canton-Massillon Area.



Traffic and Vehicle Miles Travelled

High vehicle miles travelled (VMT) and/or a high number of commuters associated with a county is generally an indicator that the county is an integral part of an urban area. Mobile source emissions of NO_x, VOC, and direct PM may contribute to ambient particulate matter that contributes to monitored violations of the NAAQS in the area. In combination with the population/population density data and the location of main transportation arteries, an assessment of VMT helps identify the probable location of nonpoint source emissions that

contribute to violations in the area. Comparatively high VMT in a county outside of the CBSA or CSA signifies integration with the core urban area contained within the CSA or CBSA, and indicates that a county with the high VMT may be appropriate to include in the nonattainment area because emissions from mobile sources in that county contribute to violations in the area. Table 7 shows 2011 VMT, while Figure 7 overlays 2011 county-level VMT with a map of the transportation arteries. The VMT used in this analysis was submitted by Ohio.

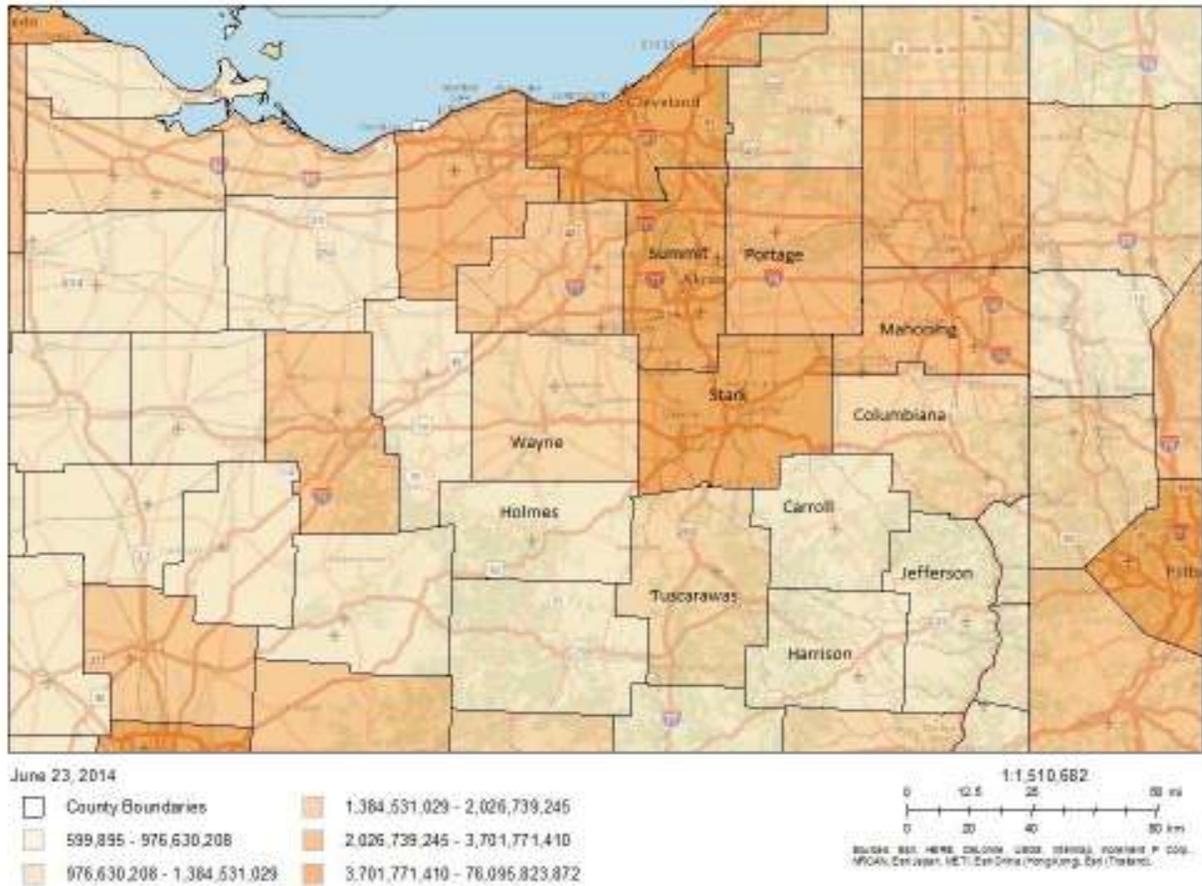
Table 7. 2011 VMT for the Canton-Massillon Area.

County, State	Total 2012 VMT	%	Cumulative %
Summit, OH	6,250,389,061	31%	31%
Stark, OH	3,838,738,336	19%	50%
Mahoning OH	2,893,842,592	14%	65%
Portage, OH	2,128,490,347	11%	75%
Wayne, OH	1,192,145,098	6%	81%
Tuscarawas, OH	1,122,381,268	6%	87%
Columbiana, OH	1,092,970,892	5%	92%
Jefferson, OH	731,496,924	4%	96%
Holmes, OH	316,674,316	2%	98%
Carroll, OH	265,377,054	1%	99%
Harrison, OH	215,789,852	1%	100%
Total	20,048,295,740		

<http://www.census.gov/hhes/commuting/data/commuting.html>

Summit County has by far the highest VMT, followed by Stark, Mahoning, and Portage Counties. As discussed below, however, meteorological considerations indicate that emissions from Mahoning County (as well as Jefferson and Columbiana counties) are unlikely to contribute to the monitored violation in Stark County. Considering the eight counties not excluded from the intended area for meteorological considerations, Summit and Stark have the highest VMT, together comprising 66% of the VMT in the eight counties. Portage County has the next highest VMT, followed by Wayne County and Tuscarawas County.

Figure 7. Overlay of 2011 County-level VMT with Transportation Arteries.



After evaluating meteorology, discussed in greater detail below under Factor 3, it becomes apparent that emissions from sources located east of the monitor are unlikely to contribute meaningfully to the monitored violation. Therefore, while Jefferson and Mahoning counties consistently have significant emissions, these emissions are unlikely to contribute meaningfully to the monitored violation recorded in Stark County. For similar meteorological reasons, Columbiana County – also located east of Stark County, but with fewer emissions than Jefferson or Mahoning counties – is also unlikely to contribute meaningfully to the monitored violation in Stark County. Therefore emissions from Stark, Summit, Wayne, Portage, Tuscarawas, Holmes, Carroll, and Harrison Counties merit closer analysis when determining contribution to the violation monitored in Stark County.

Of these eight counties, Summit County has the highest total emissions, followed by Wayne and Stark, as well as the highest NO_x, VOC, primary organic matter, and elemental carbon emissions. Wayne County has the highest SO₂ emissions and second highest overall total emissions, largely due to SO₂ emissions from two point sources. When considering emissions from the counties that cannot be reasonably excluded for meteorological reasons, Stark, Summit, and Wayne counties together comprise 72% of the total emissions, 66% of the total

direct PM_{2.5} emissions, 75% of the total population and 74% of the VMT. Although Portage County has higher population density and VMT than Wayne County, and Tuscarawas County VMT and population density are similar to that of Wayne County, emissions in Wayne County are significantly higher than emissions in either Portage or Tuscarawas counties, or in the counties of Holmes, Carroll and Harrison. Additionally, Portage, Holmes, and Harrison counties lack large singular point source contributors.

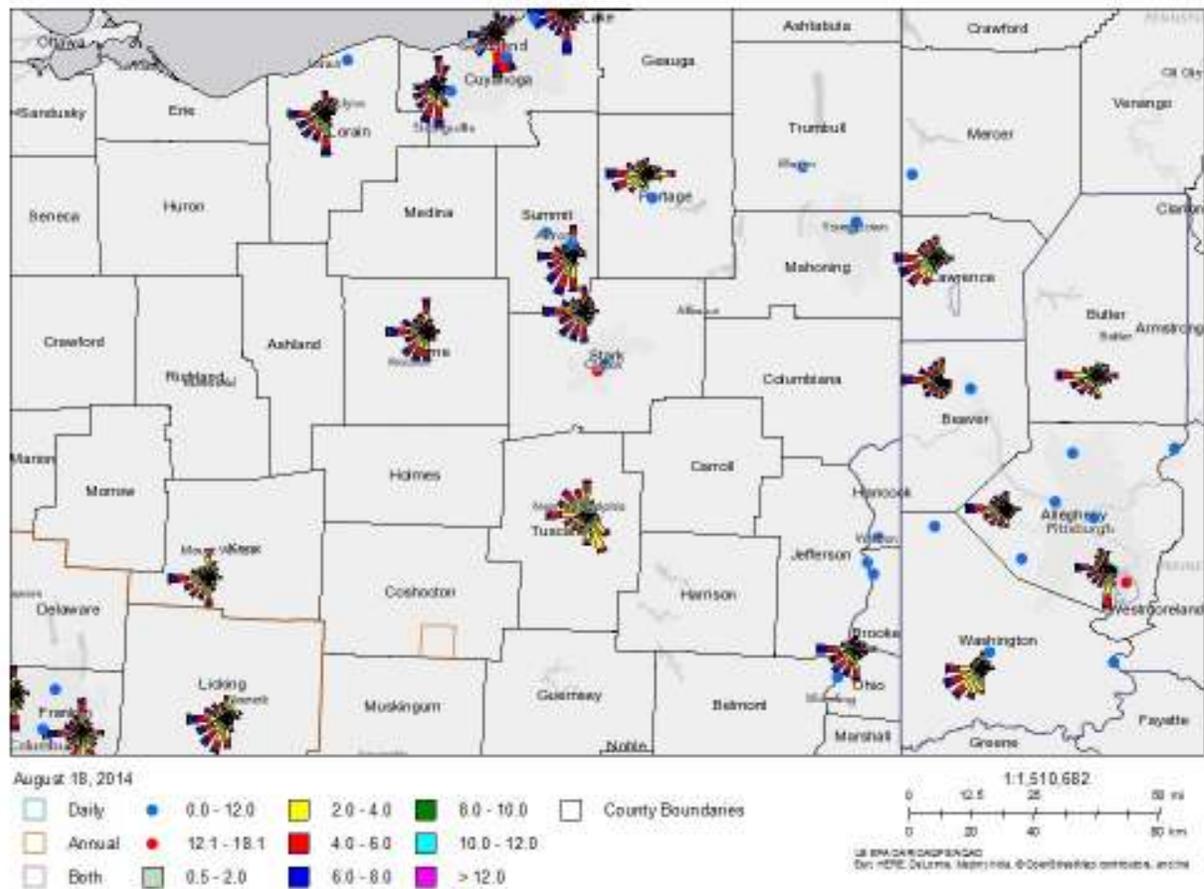
Factor 3: Meteorology

EPA evaluated available meteorological data to determine how meteorological conditions, including, but not limited to, weather, transport patterns, and stagnation conditions, could affect the fate and transport of directly emitted particulate matter and precursor emissions from sources in the area of analysis. EPA used two primary tools for this assessment: wind roses and kernel density estimation (KDE). When considered in combination with area PM_{2.5} composition and county-level and facility emissions source location information, wind roses and KDE can help to identify nearby areas contributing to violations at violating monitoring sites.

Wind roses are graphic illustrations of the frequency of wind direction and wind speed. Wind direction can indicate the direction from which contributing emissions are transported; wind speed can indicate the force of the wind and thus the distance from which those emissions are transported. EPA constructed wind roses from hourly observations of wind direction and wind speed using 2009-2012 data from National Weather Service locations archived at the National Climate Data Center.²⁹ When developing these wind roses, EPA also used wind observations collected at meteorological sampling stations collocated at air quality monitoring sites, where these data were available. Figure 8 shows wind roses that EPA generated from data relevant to the Canton-Massillon area.

²⁹ <ftp.ncdc.noaa.gov/pub/data/noaa> or <http://gis.ncdc.noaa.gov/map/viewer/#app=cdo&cfg=cdo&theme=hourly&layers=1&node=gis> Quality assurance of the National Weather Service data is described here: <http://www1.ncdc.noaa.gov/pub/data/inventories/ish-qc.pdf>

Figure 8. Wind Roses in the Area of Analysis for Canton-Massillon Area.

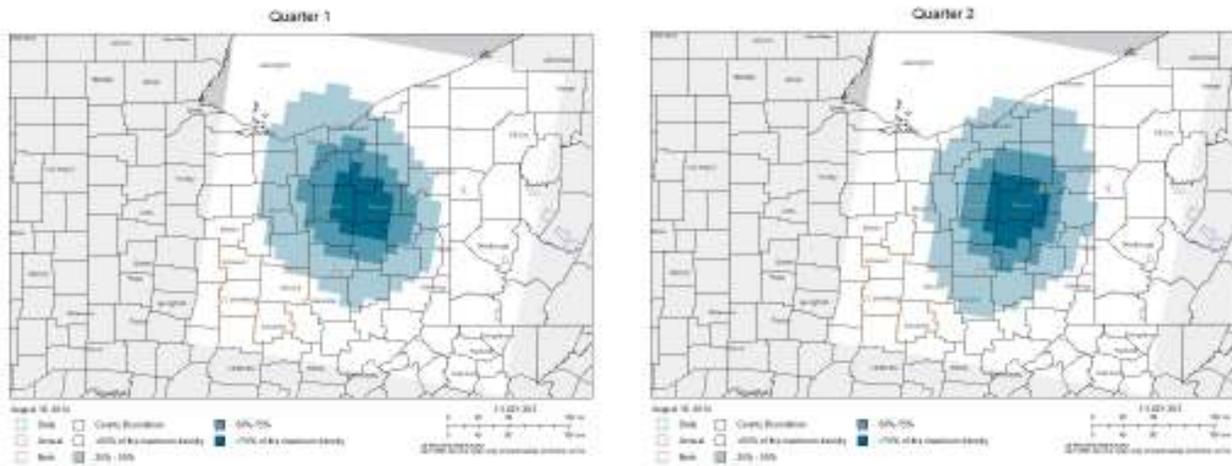


As shown in Figure 8, there is a pattern across the area of predominantly west and southwesterly winds, mostly at mid-level speeds of 4 to 10 meters per second, suggesting that potential emission sources in the south-through-west upwind direction should be considered for analysis. Some northerly winds are seen, notably in Summit County.

In addition to wind roses, EPA also generated kernel density estimation (KDE) plots to represent HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) backward trajectory frequency at violating

monitoring sites.^{30,31} These KDEs are graphical statistical estimations to determine the density of trajectory endpoints at a particular location represented by a grid cell. The EPA used KDEs to characterize and analyze the collection of individual HYSPLIT backward trajectories.³² Higher density values, indicated by darker blue colors, indicate a greater frequency of observed trajectory endpoints within a particular grid cell. Figure 9 shows a HYSPLIT KDE plot for the Canton-Massillon area summarized by calendar quarter for the 2010-2012 period. The HYSPLIT KDE is weighted in the south to westerly direction, indicating a greater frequency of trajectories passing over grid cells to the south and west. Nevertheless, these plots also suggest that impact from the north, notably including Summit County, also frequently occurs.

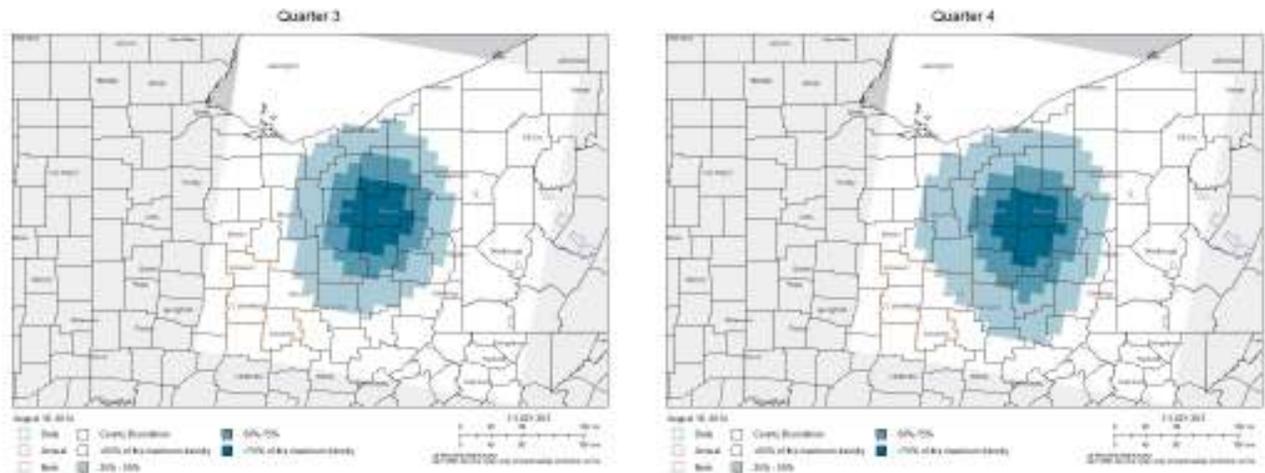
Figure 9. HYSPLIT Kernel Density Estimation Plots for the Canton-Massillon Area.



³⁰ In some past initial area designations efforts, EPA has used HYSPLIT backward trajectories to assist in determining nonattainment area boundaries. A HYSPLIT backward trajectory is usually depicted on a standard map as a single line, representing the centerline of an air parcel's motion, extending in two dimensional (x,y) space from a starting point and regressing backward in time to a point of origin. Backward trajectories may be an appropriate tool to assist in determining an air parcel's point of origin on a day in which a short-term standard, such as an 8-hour standard or a 24-hour standard, was exceeded. However, for an annual standard, such as the 2012 annual PM_{2.5} NAAQS, every trajectory on every day is important. Plotting a mass of individual daily (e.g., 365 individual back trajectories), or more frequent, HYSPLIT trajectories may not be helpful as this process is likely to result in depicting air parcels originating in all directions from the violating monitoring site.

³¹ HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory Model, http://www.arl.noaa.gov/HYSPLIT_info.php

³² The KDEs graphically represent the aggregate of HYSPLIT backward trajectories for the years 2010-2012, run every third day (beginning on the first day of monitoring), four times each day, and ending at four endpoint heights.



In summary, the HYSPLIT KDE plots and wind roses suggest that emissions from Stark, Summit, Wayne, Holmes and Tuscarawas counties (and to a lesser extent, Carroll County) have the greatest potential to reach the violating Canton-Massillon monitor. Comparison of these plots to the analogous plots for the Cleveland area further suggests that Summit and Wayne counties contribute more significantly to Stark County than to the Cuyahoga County. Accordingly, placing Summit and Wayne counties in the Canton-Massillon area may be more appropriate than placing them in the Cleveland area. The HYSPLIT KDE plots indicate relatively low density values in Jefferson, Columbiana and Mahoning counties. These counties are therefore unlikely to meaningfully impact the violation monitored in Stark County. Of particular note, the Jefferson County point sources shown in Figure 5 are located in the eastern portion of that county –along the Ohio River – and are therefore especially unlikely to have meaningful impact on the violating monitor in Stark County.

Factor 4: Geography/topography

To evaluate the geography/topography factor, EPA assessed physical features of the area of analysis that might define the airshed and thus affect the formation and distribution of PM_{2.5} concentrations over the area. The Canton-Massillon area does not have any geographical or topographical barriers inhibiting air pollution transport around the area of analysis. Therefore, this factor did not play a significant role in defining the boundary of the intended area.

Factor 5: Jurisdictional boundaries

In defining the boundaries of the intended Canton-Massillon nonattainment area, EPA considered existing jurisdictional boundaries, which can provide easily identifiable and recognized boundaries for purposes of implementing the NAAQS. Existing jurisdictional boundaries often signify well recognized boundaries that the state can easily administer and for which the state has the necessary legal authority for carrying out air quality planning and enforcement functions. Examples of such jurisdictional boundaries include existing/prior

nonattainment area boundaries for particulate matter, county lines, air district boundaries, township boundaries, areas covered by a metropolitan planning organization, state lines, and Reservation boundaries, if applicable. Where existing jurisdictional boundaries were not adequate or appropriate to describe the nonattainment area, EPA considered other clearly defined and permanent landmarks or geographic coordinates for purposes of identifying the boundaries of the intended designated areas.

The Canton-Massillon Metropolitan Statistical Area consists of Stark and Carroll Counties. The Canton-Massillon area also has previously established nonattainment boundaries, consisting of Stark County, associated with the 2006 24-hour and 1997 annual PM_{2.5} NAAQS. Summit and Portage counties were previously designated nonattainment as part of the Cleveland area for both the 1997 and 2006 PM_{2.5} NAAQS. The state has recommended that only Stark County be included in the Canton-Massillon nonattainment area for the 2012 annual PM_{2.5} NAAQS.

In addition to counties, the Bureau of Census recognizes legally defined county subdivisions, referred to as “minor civil divisions.” For Ohio, these minor civil divisions consist of townships and cities. When considering Wayne County’s contribution to the violation monitored in Stark County, major point source emissions were of particular concern. Limiting the nonattainment portion of Wayne County to the following Bureau of Census defined minor civil divisions captures the three major sources in Wayne County and establishes a contiguous nonattainment area with clearly defined legal boundaries: Baughman, Chippewa, Green, and Milton townships and the portion of Norton City located within Wayne County. This sub-county area consists of approximately the northeast quarter of the county.

Conclusion for the Canton-Massillon Area

Based on the assessment of factors described above, both individually and in combination, EPA has preliminarily concluded that the following counties should be included as part of the Canton-Massillon nonattainment area because they are either violating the 2012 annual PM_{2.5} NAAQS or contributing to a violation in a nearby area: Stark County, Summit County, and Wayne County (partial). These are not the same boundaries that were promulgated for the Canton-Massillon nonattainment area for the 2006 24-hour and 1997 annual PM_{2.5} NAAQS.

The air quality monitoring site in Stark County indicates a violation of the 2012 annual PM_{2.5} NAAQS based on the 2011-2013 DV; therefore this county is included in the nonattainment area. Summit and Wayne counties are nearby counties that do not have violating monitoring sites, but EPA has concluded that these areas contribute to the particulate matter concentrations in violation of the 2012 annual PM_{2.5} NAAQS.

Jefferson and Mahoning counties have among the highest emissions of directly emitted PM_{2.5} and/or PM_{2.5} precursors in the area, however, Jefferson and Mahoning counties are frequently downwind of the violating monitor, as is Columbiana County, and emissions from these counties are unlikely to have a meaningful impact on the concentrations at the violating monitor. Of the eight other counties in the area of analysis, Summit County has the highest total emissions, followed by Wayne and Stark, as well as the highest NO_x, VOC, primary organic matter, and elemental carbon emissions. Stark County has the highest total direct PM_{2.5}

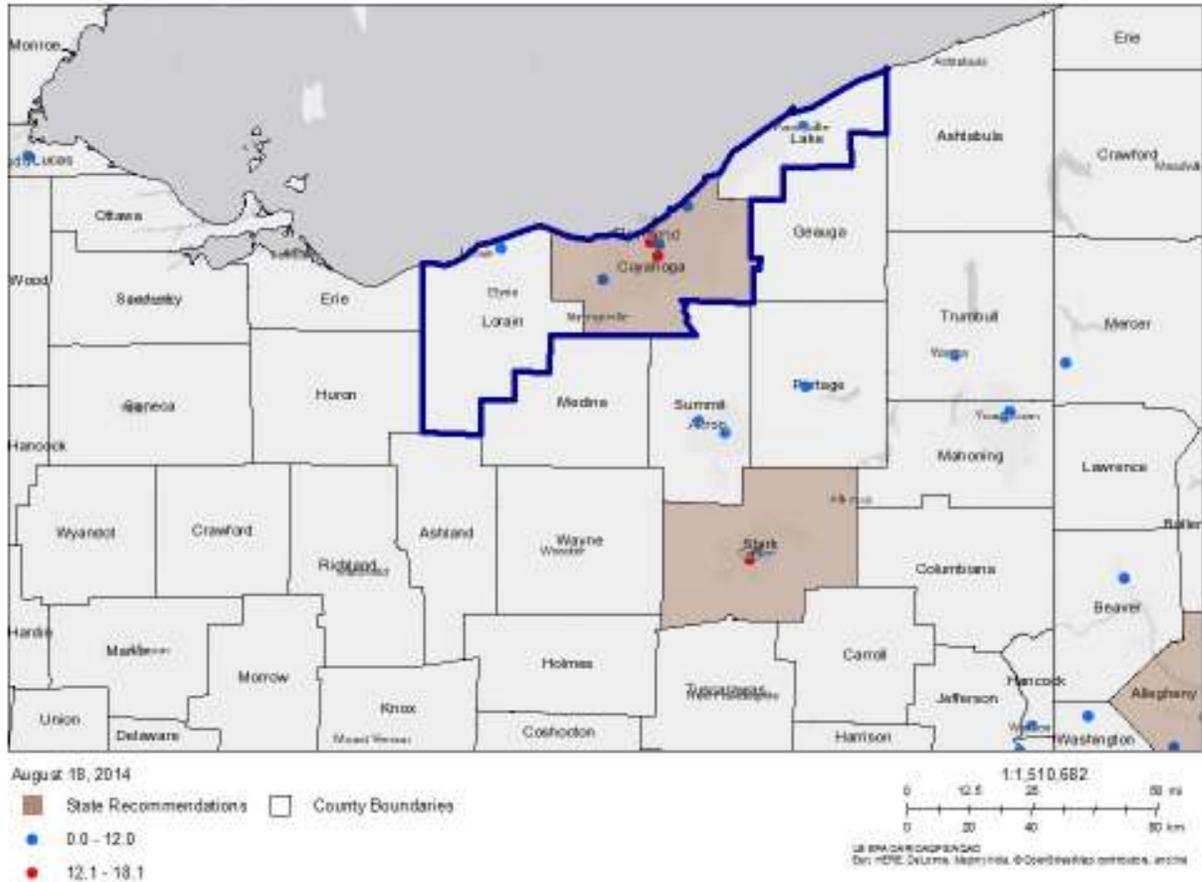
emissions, followed by Wayne and Summit, as well as the highest crustal and second highest NO_x, VOC, primary organic mass and elemental carbon. Wayne County has the highest SO₂ emissions and second highest overall total emissions, largely due to SO₂ emissions from two point sources. Including the portion of Wayne County consisting of Baughman, Chippewa, Green, and Milton townships and the portion of Norton City located within Wayne County captures the three major sources listed in Table 5 – the majority of the emissions in Wayne County. Stark, Summit, and Wayne counties together comprise 72% of the total emissions, 66% of the total direct PM_{2.5} emissions, 75% of the total population and 74% of the VMT in the eight counties not excluded for primarily meteorological reasons. Portage County is most often somewhat downwind, being located northeast of the Canton-Massillon monitor, and has relatively lower emissions as compared to Stark, Summit, and Wayne Counties. Finally, although Carroll County is in the Canton-Massillon MSA, it has relatively lower emissions, population density and VMT as compared to Stark, Summit, and Wayne counties. Accordingly, it is unlikely to contribute meaningfully to the violation in Stark County.

3.2 Area Background and Overview Cleveland

Figure 1a is a map of EPA's intended nonattainment boundary for the Cleveland nonattainment area. The map shows the location and design values of ambient air quality monitoring locations, county boundaries and Ohio's recommended nonattainment boundary.

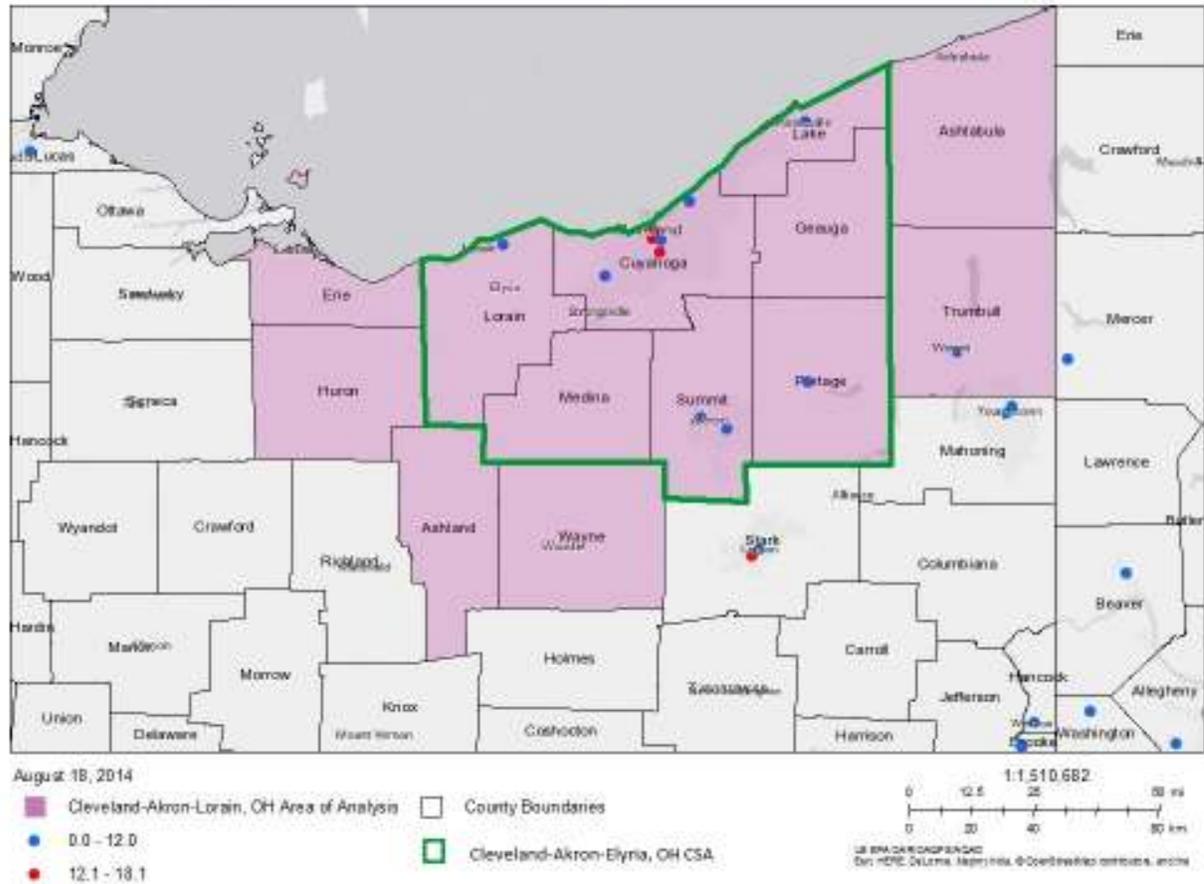
For purposes of the 1997 annual PM_{2.5} NAAQS, portions of this area were designated nonattainment. The boundary for the nonattainment area for the 1997 annual PM_{2.5} NAAQS included the entire counties of Cuyahoga, Lake, Lorain, Medina, Portage, and Summit, and parts of Ashtabula County. For purposes of the 2006 24-hour PM_{2.5} NAAQS, all of this area minus the portion of Ashtabula County was designated nonattainment. That is, the boundary for the nonattainment area for the 2006 24-hour PM_{2.5} NAAQS included the entire counties of Cuyahoga, Lake, Lorain, Medina, Portage, and Summit Counties.

Figure 1a. EPA’s Intended Nonattainment Boundaries for the Cleveland, OH Area



EPA must designate as nonattainment areas that violate the NAAQS and nearby areas that contribute to the violation in the violating area. Cuyahoga County shows violations of the 2012 PM_{2.5} NAAQS, therefore this county is included in the nonattainment area of analysis. As shown in Figure 1b, EPA also evaluated each county without a violating monitoring site located in or near the combined statistical area (CSA) of the county with a violating monitoring site based on the five factors and other relevant information, and determined that Lake and Lorain counties contribute to the nearby violations in Cuyahoga County. The following sections describe this five factor analysis process. While the factors are presented individually, they are not independent. The five factor analysis process carefully considers their interconnections and the dependence of each factor on one or more of the others.

Figure 1b. Area of Analysis for the Cleveland, OH Area



Factor 1: Air Quality Data

All data collected during the year are important when determining contributions to an annual standard such as the 2012 annual PM_{2.5} NAAQS. Compliance with an annual NAAQS is dependent upon monitor readings throughout the year, including days with monitored ambient concentrations below the level of the NAAQS. For the 2012 annual PM_{2.5} NAAQS, the annual mean is calculated as the mean of quarterly means. A high quarter can drive the mean for an entire year, which, in turn, can drive an elevated 3-year DV. Although all data are important, seasonal or episodic emissions can provide insight as to relative contributors to measured PM_{2.5} concentrations. For these reasons, for the Factor 1 air quality analysis, EPA assessed and characterized air quality at, and in the proximity of, the violating monitoring site locations first, by evaluating trends and the spatial extent of measured concentrations at monitors in the area of analysis, and then, by identifying the conditions most associated with high average concentration levels of PM_{2.5} mass in the area of analysis.

In most cases, EPA assessed air quality data on a seasonal, or quarterly, basis.³³ EPA also identified the spatial extent of these high PM_{2.5} concentrations. The mass and composition at the design value location represents contributions from various emission sources including local, area-wide (which may comprise nearby urban and rural areas) and regional sources. To determine the source mix (by mass) at the design value monitoring site, EPA examined the chemical composition of the monitored PM_{2.5} concentrations by pairing each violating FRM/FEM/ARM monitoring site with a collocated or nearby Chemical Speciation Network (CSN) monitoring site or sites. Then, EPA contrasted the approximated mass composition at the design value monitoring site with data collected at IMPROVE³⁴ and other monitoring locations whose data are representative of regional background.^{35,36} This comparison of local/area-wide chemical composition data to regional chemical composition data derives an “urban increment,” which helps differentiate the influence of more distant

³³ Although compliance with the annual NAAQS depends on contributions from all days of the year, examining data on a quarterly or seasonal basis can inform the relationship between the temporal variability of emissions and meteorology and the resulting PM_{2.5} mass and composition. In some areas of the country where there may be noticeable month-to-month variations in average PM_{2.5}, the quarterly averages may not adequately represent seasonal variability. In these areas, air quality data may be aggregated and presented by those months that best correspond to the local “seasons” in these areas.

³⁴ IMPROVE stands for Interagency Monitoring for Protected Visual Environments and is an aerosol monitoring network in mostly rural and remote areas.

³⁵ The “urban increment” analysis assesses and characterizes the increase in seasonal and annual average PM_{2.5} mass and chemical constituents observed at violating monitoring site(s) relative to monitoring sites outside the area of analysis (which represent background concentrations). Developing the urban increment involves pairing a violating FRM/FEM/ARM monitor with a collocated monitor or nearby monitor with speciation data. EPA made every effort to pair these data to represent the same temporal and spatial scales. However, in some cases, the paired violating and CSN “urban” monitoring locations were separated by some distance such that the included urban CSN site(s) reflect(s) a different mixture of emissions sources, which could lead to misinterpretations. To generally account for differences in PM_{2.5} mass between the violating site and the nearby CSN site(s), EPA determined material balance of the PM_{2.5} composition at the violating site by assigning the extra measured PM_{2.5} mass to the carbon components of PM_{2.5}. Where the general urban increment approach may be misleading, or in situations where non-carbonaceous emissions are believed to be responsible for a local PM_{2.5} concentration gradient, EPA used alternative analyses to reflect the mix of urban and rural sources contributing to the measured concentrations at violating monitoring sites.

³⁶ The urban monitors were paired with any rural sites within a 150 mile radius of an urban site to calculate spatial means of the quarterly averages of each species. If there were no rural sites within 150 miles, then the nearest rural site was used alone. That rural mean was then subtracted from the quarterly mean of the urban site to get the increment. Negative values were simply replaced with zeroes.

emissions sources from the influence of closer emissions sources, thus representing the portion of the measured violation that is associated with nearby emission contributions.^{37,38,39}

PM_{2.5} Design Values and Total Mass Measurements - EPA examined ambient PM_{2.5} air quality monitoring data represented by the DVs at the violating monitoring site and at other monitors in the area of analysis. EPA calculated DVs based on air quality data for the most recent 3 consecutive calendar years of quality-assured, certified air quality data from suitable FEM/FRM/ARM monitoring sites in the EPA’s Air Quality System (AQS). For this designations analysis, EPA used data for the 2011-2013 period (i.e., the 2013 design value), which are the most recent years with fully-certified air quality data. A monitor’s DV is the metric or statistic that indicates whether that monitor attains a specified air quality standard. The 2012 annual PM_{2.5} NAAQS is met at a monitoring site when the 3-year average annual mean concentration is 12.0 micrograms per cubic meter (µg/m³) or less (e.g., 12.1 µg/m³ or greater is a violation). A DV is only valid if minimum data completeness criteria are met or when other regulatory data processing provisions are satisfied (See 40 CFR part 50 Appendix N). Table 2 identifies the current design values (i.e., the 2013 DV) and the most recent two additional design values based on all monitoring sites in the area of analysis for the Cleveland area.⁴⁰ Where a county has more than one monitoring location, the county design value is indicated in red type.

Table 2. Air Quality Data collected at Regulatory Monitors (all DV levels in µg/m³)^a

County, State	Monitor Site ID	State Rec NA?	09-11 DV	10-12 DV	11-13 DV
Ashland, OH	N/A	No	No monitor		
Ashtabula, OH	N/A	No	No monitor		
Cuyahoga, OH	390350034	Yes	10.4	10.1	9.6

³⁷ In most, but not all, cases, the violating design value monitoring site is located in an urban area. Where the violating monitor is not located in an urban area, the “urban increment” represents the difference between local and other nearby emission sources in the vicinity of the violating monitoring location and more regional sources.

³⁸ Hand, et. al. Spatial and Seasonal Patterns and Temporal Variability of Haze and its Constituents in the United States: Report V, June 2011. Chapter 7 – Urban Excess in PM_{2.5} Speciated Aerosol Concentrations, <http://vista.cira.colostate.edu/improve/Publications/Reports/2011/PDF/Chapter7.pdf>

³⁹ US EPA, Office of Air Quality Planning and Standards, December 2004. (2004) Area Designations for 1997 Fine Particle (PM_{2.5}) Standards, Technical Support Document for State and Tribal Air Quality Fine Particle (PM_{2.5}) Designations, Chapter 3, Urban Excess Methodology. Available at www.epa.gov/pmdesignations/1997standards/documents/final/TSD/Ch3.pdf

⁴⁰ In certain circumstances, one or more monitoring locations within a monitoring network may not meet the network technical requirements set forth in 40 CFR 58.11(e), which states, “State and local governments must assess data from Class III PM_{2.5} FEM and ARM monitors operated within their network using the performance criteria described in table C-4 to subpart C of part 53 of this chapter, for cases where the data are identified as not of sufficient comparability to a collocated FRM, and the monitoring agency requests that the FEM or ARM data should not be used in comparison to the NAAQS. These assessments are required in the monitoring agency’s annual monitoring network plan described in §58.10(b) for cases where the FEM or ARM is identified as not of sufficient comparability to a collocated FRM....”

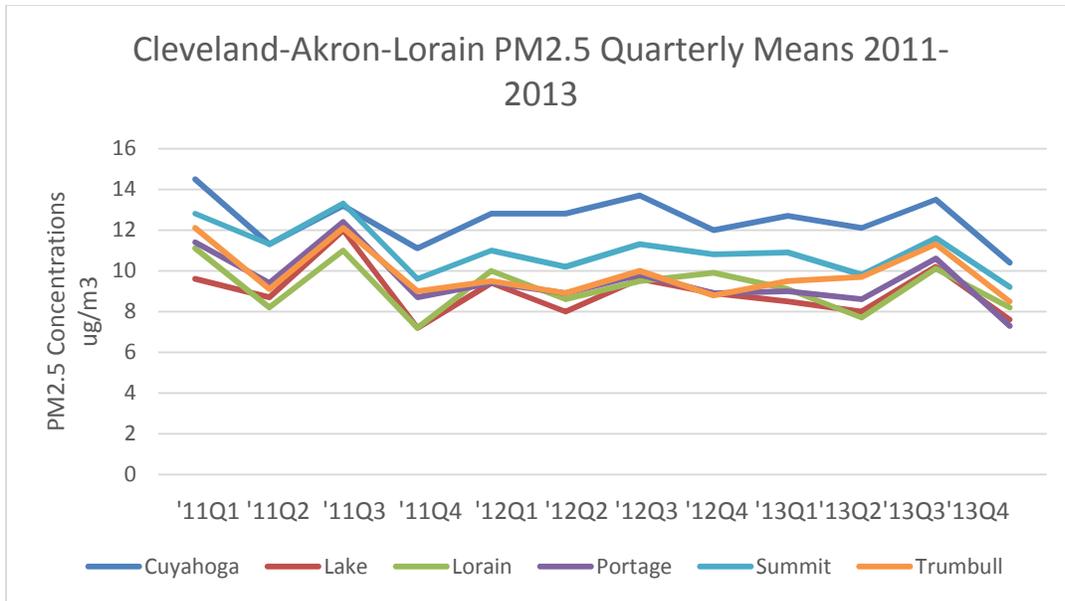
County, State	Monitor Site ID	State Rec NA?	09-11 DV	10-12 DV	11-13 DV
Cuyahoga, OH	390350038	Yes	13.1	13.0	12.4
Cuyahoga, OH	390350045	Yes	12.3	12.2	11.5
Cuyahoga, OH	390350060	Yes	12.8	13.0	12.5
Cuyahoga, OH	390350065	Yes	12.7	12.7	12.1
Cuyahoga, OH	390351002	Yes	10.9	10.5	9.7
Erie, OH	N/A	No	No monitor		
Geauga, OH	N/A	No	No monitor		
Huron, OH	N/A	No	No monitor		
Lake, OH	390850007	No	10.1	9.6	9.0
Lorain, OH	390933002	No	9.9	9.7	9.2
Medina, OH	N/A	No	No monitor		
Portage, OH	391330002	No	10.9	10.3	9.5
Stark, OH	391510017	No	13.4	13.0	12.1
Stark, OH	391510020	No	12.3	11.8	10.8
Summit, OH	391530017	No	12.6	12.0	11.0
Summit, OH	391530023	No	11.7	11.2	10.4
Trumbull, OH		No	11.3 NV	10.6	9.9
Wayne, OH	N/A	No	No monitor		

^aWhere a county has more than one monitoring location, the county design value is indicated in red type.

The Figure 1 map, shown previously, identifies the Cleveland intended nonattainment area, the CSA boundary, and monitoring locations with 2011-2013 violating DVs. As indicated on the map, there are 3 violating monitoring locations located in Cuyahoga County in the central Cleveland area, an industrialized area. There has been a modest decline in monitored values and there is no strong intra-annual trend other than lower values in the fourth quarter. The monitors outside of the central Cleveland area, including other monitors in Cuyahoga County, are not violating in the 2011-2013 time period.

Seasonal variation can highlight those conditions most associated with high average concentration levels of PM_{2.5}. Figure 2 shows quarterly mean PM_{2.5} concentrations for the most recent 3-year period for the highest DV monitoring sites and other, non-violating, monitoring sites in each county within the area of analysis. This graphical representation is particularly relevant when assessing air quality data for an annual standard, such as the 2012 annual PM_{2.5} NAAQS, because, as previously stated, the annual mean is calculated as the mean of quarterly means and a high quarter can drive the mean for an entire year, which, in turn, can drive an elevated 3-year DV.

Figure 2. Cleveland PM_{2.5} Quarterly Means for 2011-2013



As shown in Figure 2, there is a modest decline in monitored values from 2011 through 2013. Although Q4 values are a little lower, there are no strong seasonal trends

PM_{2.5} Composition Measurements - To assess potential emissions contributions for each violating monitoring location, the EPA determined the various chemical species comprising total PM_{2.5} to identify the chemical constituents over the analysis area, which can provide insight into the types of emission sources impacting the monitored concentration. To best describe the PM_{2.5} at the violating monitoring location, EPA first adjusted the chemical speciation measurement data from a monitoring location at or near the violating FRM monitoring site using the SANDWICH approach to account for the amount of PM_{2.5} mass constituents retained in the FRM

measurement.^{41,42,43,44} In particular, this approach accounts for losses in fine particle nitrate and increases in sulfate mass associated with particle bound water. Figure 3a illustrates the fraction of each PM_{2.5} chemical constituent at the Cleveland 39-035-0060 monitoring site based on annual averages for the years 2011-2013.

Figure 3a. Cleveland-Akron-Lorain Annual Average PM_{2.5} Chemical Constituents (2010-2012)

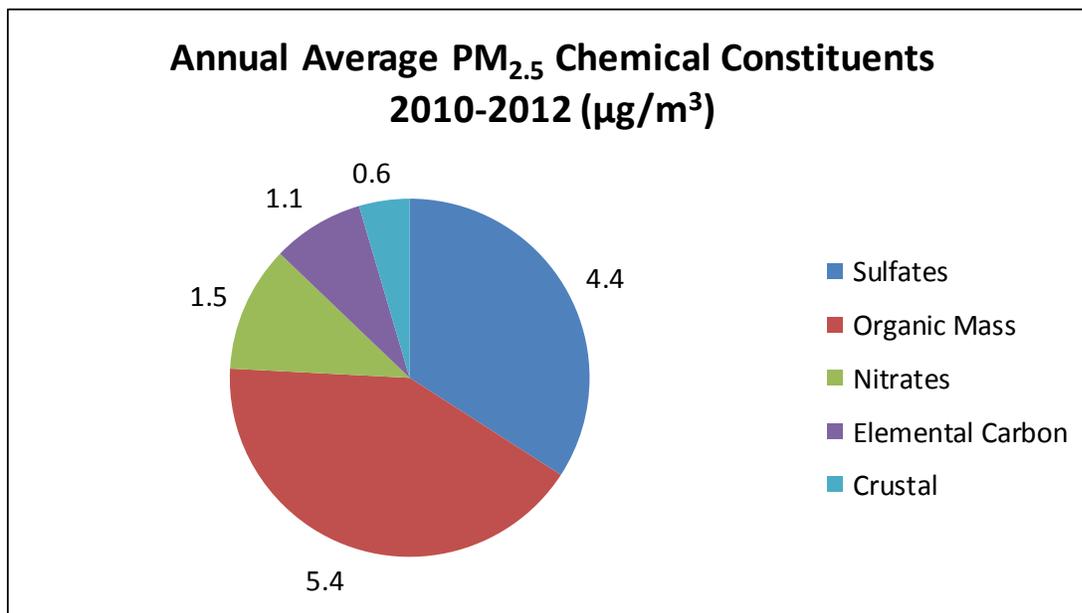


Figure 3b shows annual and quarterly chemical composition profiles and illustrates any seasonal or episodic contributors to PM_{2.5} mass. This “increment analysis,” combined with the other factor analyses, can provide

⁴¹ SANDWICH stands for measured Sulfate, Adjusted Nitrate, Derived Water, Inferred Carbonaceous mass Hybrid Material Balance Approach.” The SANDWICH adjustment uses an FRM mass construction methodology that results in reduced nitrates (relative to the amount measured by routine speciation networks), higher mass associated with sulfates (reflecting water included in gravimetric FRM measurements) and a measure of organic carbonaceous mass derived from the difference between measured PM_{2.5} and its non-carbon components. This characterization of PM_{2.5} mass also reflects crustal material and other minor constituents. The resulting characterization provides a complete mass closure for the measured FRM PM_{2.5} mass, which can be different than the data provided directly by the speciation measurements from the CSN network.

⁴² Frank, N. H., SANDWICH Material Balance Approach for PM_{2.5} Data Analysis, National Air Monitoring Conference, Las Vegas, Nevada, November 6-9, 2006. <http://www.epa.gov/ttn/amtic/files/2006conference/frank.pdf>.

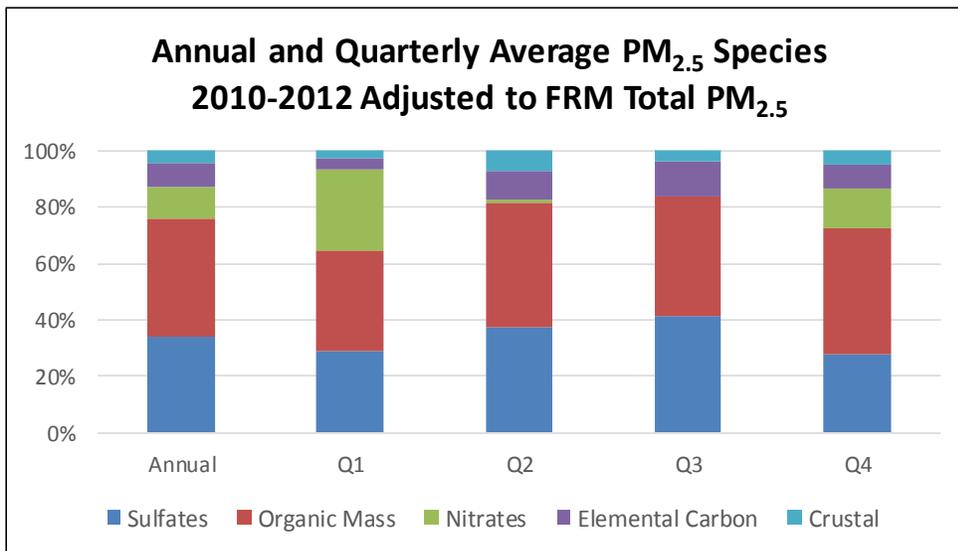
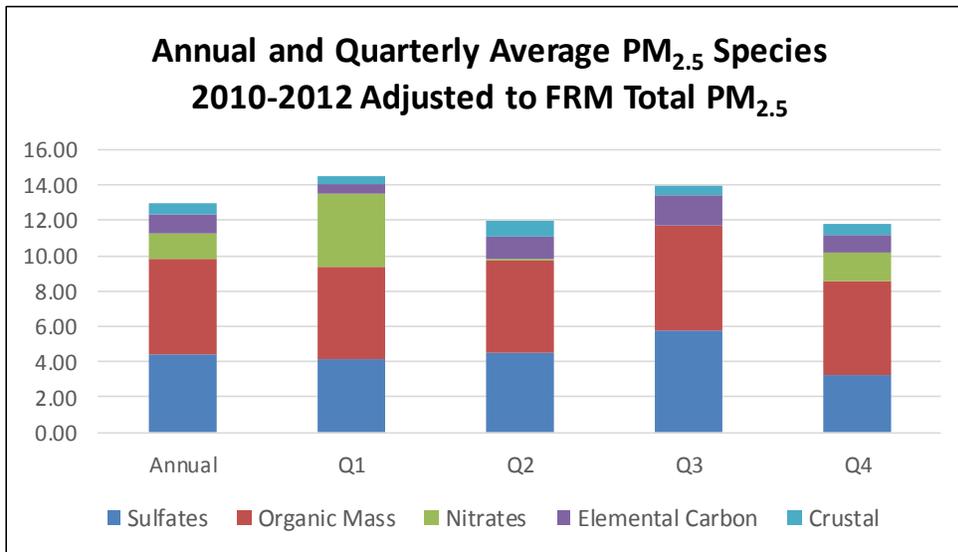
⁴³ Frank, N. H., The Chemical Composition of PM_{2.5} to support PM Implementation, EPA State /Local/Tribal Training Workshop: PM_{2.5} Final Rule Implementation and 2006 PM_{2.5} Designation Process, Chicago IL, June 20-21, 2007, http://www.epa.gov/ttn/naaqs/pm/presents/pm2.5_chemical_composition.pdf.

⁴⁴ Frank, N. H. *Retained Nitrate, Hydrated Sulfates, and Carbonaceous Mass in Federal Reference Method Fine Particulate Matter for Six Eastern U.S. Cities*. J. Air & Waste Manage. Assoc. 2006 56:500–511.

additional insight as to which sources or factors may contribute at a greater level. Simply stated, this analysis can help identify nearby sources of emissions that contribute to the violation at the violating monitoring sites.

Figure 3b shows that sulfate and OM are the predominant species overall, with an exception in Q1 when nitrate is similar to sulfate levels. Crustal is a relatively small component, with the highest crustal concentrations in Q2. This suggests that power plants, other stationary sources and vehicles are the largest source of emissions.

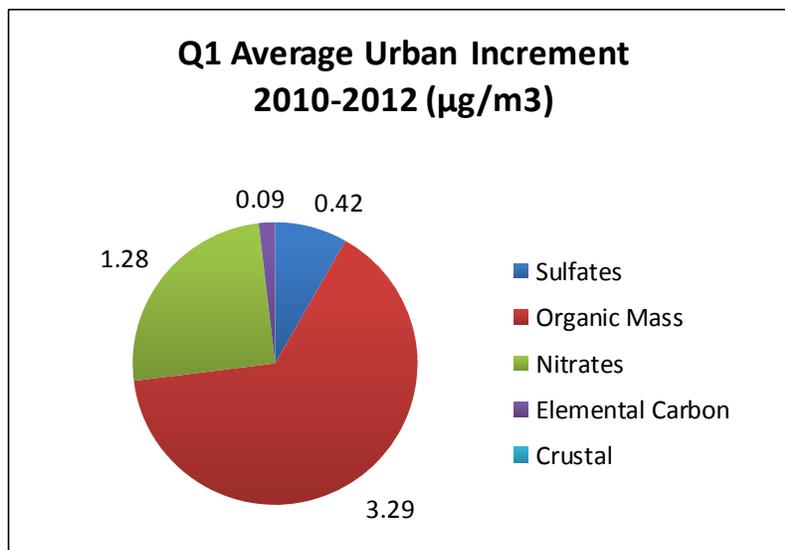
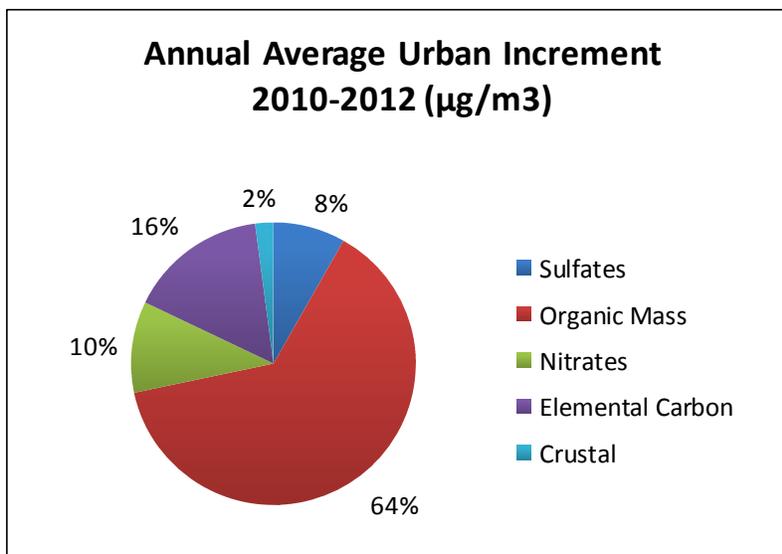
Figure 3b. Cleveland Annual and Quarterly Average PM_{2.5} Species (2010-2012)^a



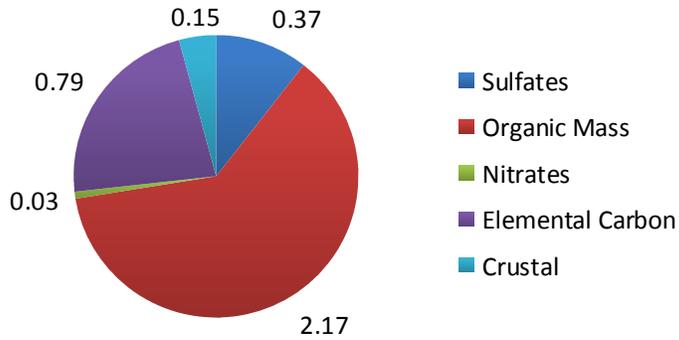
^aAdjusted to FRM Total PM_{2.5} indicates that the speciation profile and total mass depicted in this figure are the result of the urban increment calculation for the particular FRM monitor.

EPA assessed seasonal and annual average PM_{2.5} constituents at monitoring sites within the area relative to monitoring sites outside of the analysis area to account for the difference between regional background concentrations of PM_{2.5}, and concentrations of PM_{2.5} in the area of analysis, also known as the “urban increment.” This analysis differentiates between the influences of emissions from sources in nearby areas and in more distant areas on the violating monitor. Estimating the urban increment in the area helps to illuminate the amount and type of particles at the violating monitor that are most likely to be the result of sources of emissions in nearby areas, as opposed to impacts of more distant or regional sources of emissions. Figure 4a includes pie charts showing the annual and quarterly chemical mass constituents of the urban increment. The quarterly pie charts correspond to the 2011-2012 high-concentration quarters identified in Figure 2. Evaluating these high concentration quarters can help identify composition of PM_{2.5} during these times. Note that in these charts, sulfates and nitrates have been adjusted to represent their mass in measured PM_{2.5}.

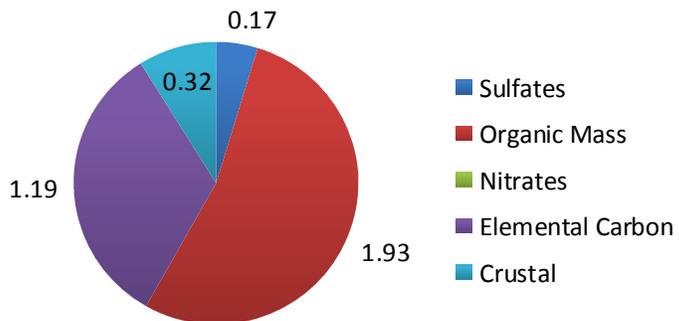
Figure 4a. Cleveland Urban Increment Analysis for 2010-2012.



**Q2 Average Urban Increment
2010-2012 ($\mu\text{g}/\text{m}^3$)**



**Q3 Average Urban Increment
2010-2012 ($\mu\text{g}/\text{m}^3$)**



**Q4 Average Urban Increment
2010-2012 ($\mu\text{g}/\text{m}^3$)**

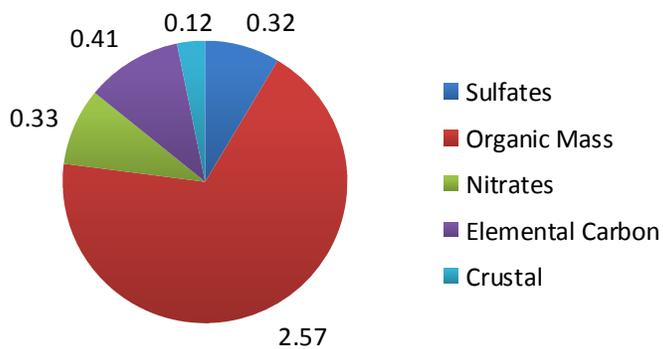
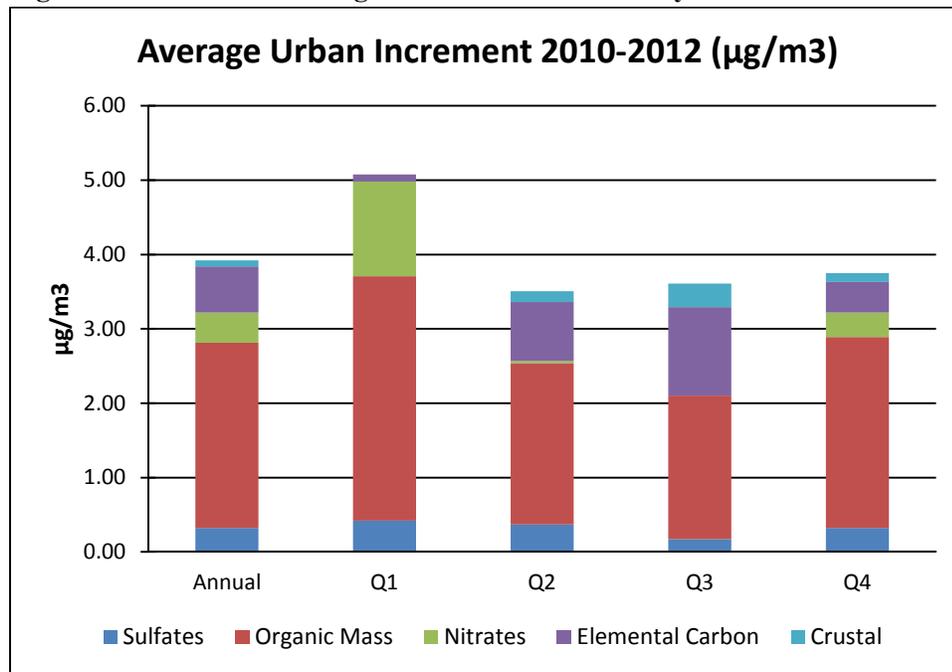


Figure 4b. Cleveland Average Urban Increment Analysis for 2010-2012.



As shown in Table 2, Cuyahoga County has three monitoring site with a DV exceeding the NAAQS. In addition, Figure 2 shows that Cuyahoga and adjoining counties have experienced a modest decline in ambient concentrations since 2010. Although Q4 values are a little lower, there are no strong seasonal trends.

In reviewing the urban increment analysis for the Cleveland CSA DV monitor, organic mass is the largest $\text{PM}_{2.5}$ chemical consistent and shows a large urban contribution. While the sulfate component appears to have small urban contribution and therefore large regional contribution, its values are higher than what was shown for the Canton area, particularly for quarters 1, 2 and 4. Nitrate is the second highest urban increment component for the quarter 1 peak, but is not a factor in the quarter 3 peak season, during which period both carbon components comprise high percentages of the total. The majority of the contributions come from carbonaceous sources. As shown in the next section, these include direct emission POC, EC as well as VOC. In addition, the urban increment shows that a substantial nearby contribution appears to result from other $\text{PM}_{2.5}$ precursors – including NO_x and SO_2 .

Factor 2: Emissions and emissions-related data

In this designations process, for each area with a violating monitoring site, EPA evaluated the emissions data from nearby areas using emissions related data for the relevant counties to assess each county’s potential contribution to $\text{PM}_{2.5}$ concentrations at the violating monitoring site or monitoring sites in the area under evaluation. However, seasonal emissions trends are not significantly different, and the seasonal patterns are similar for all major emitted pollutants; therefore EPA is only analyzing annual emissions data. (Although nitrate is much higher in the cooler months, NO_x emissions have similar importance all year due to their role in fostering the photochemistry that causes secondary particulate matter.)

EPA examined emissions of identified sources or source categories of direct PM_{2.5}, the major components of direct PM_{2.5} (organic mass, elemental carbon, crustal material (and/or individual trace metal compounds)), primary nitrate and primary sulfate, and precursor gaseous pollutants (i.e., SO₂, NO_x, total VOC, and NH₃). EPA also considered the distance of those sources of emissions from the violating monitoring site. While direct PM_{2.5} emissions and its major carbonaceous components are generally associated with sources near violating PM_{2.5} monitoring sites, the gaseous precursors tend to have a more regional influence (although the EPA is mindful of the potential for local NO_x and VOC emissions contributions to PM_{2.5} from mobile and stationary sources) and transport from neighboring areas can contribute to higher PM_{2.5} levels at the violating monitoring sites.

Emissions Data

For this factor, EPA reviewed data from the 2011 National Emissions Inventory (NEI) [version 1](http://www.epa.gov/ttn/chief/net/2011inventory.html) (see <http://www.epa.gov/ttn/chief/net/2011inventory.html>). For each county in the area of analysis, EPA examined the magnitude of county-level emissions reported in the NEI. These county-level emissions represent the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, nonroad mobile, on-road mobile, and fires. EPA also looked at the geographic distribution of major point sources of the relevant pollutants.⁴⁵ Significant emissions levels from sources in a nearby area indicate the potential for the area to contribute to monitored violations.

To further analyze area emissions data, EPA also developed a summary of direct PM_{2.5}, components of direct PM_{2.5}, and precursor pollutants, which is available at <http://www.epa.gov/pmdesignations/2012standards/docs/nei2011v1pointnei2008v3county.xlsx>.

When considered with the urban increment analysis in Factor 1, evaluating the components of direct PM_{2.5} and precursor gases can help identify specific sources or source types contributing to elevated concentrations at violating monitoring sites and thus assist in identifying appropriate area boundaries. In general, directly emitted particulate organic carbon (POC) and VOCs⁴⁶ contribute to PM_{2.5} organic mass (OM); directly emitted EC contributes to PM_{2.5} EC; NO_x, NH₃ and directly emitted nitrate contribute to PM_{2.5} nitrate mass; SO₂, NH₃ and directly emitted sulfate contribute to PM_{2.5} sulfate mass; and directly emitted crustal material and metal oxides contribute to PM_{2.5} crustal matter.^{47,48} EPA believes that the quantities of those nearby emissions as potential contributors to the PM_{2.5} violating monitors are somewhat proportional to the PM_{2.5} chemical constituents in the estimated urban increment. Thus, directly emitted POC is more important per ton than SO₂, partially because

⁴⁵ For purposes of this designations effort, “major” point sources are those whose sum of PM precursor emissions (PM_{2.5} + NO_x + SO₂ + VOC + NH₃) are greater than 500 tons per year based on NEI 2011v1.

⁴⁶ As previously mentioned, nearby VOCs are presumed to be a less important contributor to PM_{2.5} OM than POC.

⁴⁷ See, Seinfeld J. H. and Pandis S. N. (2006) *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, 2nd edition, J. Wiley, New York. See also, Seinfeld J. H. and Pandis S. N. (1998) *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, 1st edition, J. Wiley, New York.

⁴⁸ USEPA Report (2004), The Particle Pollution Report: Current Understanding of Air Quality and Emissions through 2003, found at: <http://www.epa.gov/airtrends/aqtrnd04/pm.html>.

POC emissions are already PM_{2.5} whereas SO₂ must convert to PM_{2.5} and not all of the emitted SO₂ undergoes this conversion.

Table 3a provides a county-level emissions summary (i.e., the sum of emissions from the following general source categories: point sources, non-point (i.e., area) sources, nonroad mobile, on-road mobile, and fires) of directly emitted PM_{2.5} and precursor species for the county with the violating monitoring site and nearby counties considered for inclusion in the Cleveland area. Table 3b summarizes the directly emitted components of PM_{2.5} for the same counties in the area of analysis for the Cleveland area. This information will be considered in conjunction with the Urban Increment composition information previously shown in Figures 4a and 4b.

Table 3a. County-Level Emissions of Directly Emitted PM_{2.5} and Precursors (tons/year)

County, State	Total NH ₃	Total NO _x	Total Direct PM _{2.5}	Total SO ₂	Total VOC	Total
Lake, OH	211	17,875	6,250	52,697	7,828	84,862
Cuyahoga, OH	1,097	34,631	4,831	6,916	31,734	79,209
Lorain, OH	565	14,793	1,997	32,558	9,302	59,215
Summit, OH	495	16,925	1,760	4,310	13,110	36,601
Wayne, OH	3,868	7,323	2,080	18,028	4,637	35,937
Stark, OH	2,159	14,466	2,471	566	12,424	32,085
Ashtabula, OH	737	6,878	1,237	3,765	7,894	20,511
Portage, OH	473	6,428	858	170	5,604	13,533
Medina, OH	366	5,496	867	162	4,834	11,724
Geauga, OH	345	2,837	612	261	3,473	7,528

Table 3b. County-Level Emissions for Components of Directly Emitted PM_{2.5} (tons/year)⁴⁹

County, State	POM	EC	PSO4	PNO3	Pcrustal	Residual	Total Direct
Lake, OH	593	396	445	4	2,175	2,638	6,250
Cuyahoga, OH	2,166	946	184	17	648	871	4,831
Stark, OH	738	375	124	6	616	612	2,471
Wayne, OH	418	186	106	3	598	769	2,080
Lorain, OH	525	317	101	4	458	591	1,997
Summit, OH	857	451	36	3	179	234	1,760
Ashtabula, OH	404	194	48	3	245	343	1,237
Medina, OH	407	178	12	1	117	152	867
Portage, OH	390	201	15	2	103	147	858
Geauga, OH	329	112	11	1	57	101	612

Table 3b breaks down the direct PM_{2.5} emissions value from Table 3a into its components. These data will also be compared with the previously presented Urban Increment composition.

Using the previously described relationship between directly emitted and precursor gases and the measured mass to evaluate data presented in Tables 3a and 3b, EPA identified the following components warranting additional review: For the Cleveland area, the constituents of interest are NO_x, POM, EC, PNO₃, SO₂, and PSO₄. EPA then looked at the contribution of these constituents of interest from each of the counties included in the area of analysis as shown in Tables 4a-f.

Table 4a. County-Level NO_x Emissions (tons/year)

County, State	Emissions in average tons/yr		
	NOX	Pct.	Cumulative %
Cuyahoga, OH	34,631	27%	27%
Lake, OH	17,875	14%	41%
Summit, OH	16,925	13%	54%
Lorain, OH	14,793	12%	66%
Stark, OH	14,466	11%	77%
bWayne, OH	7,323	6%	83%
Ashtabula, OH	6,878	5%	88%
Portage, OH	6,428	5%	93%
Medina, OH	5,496	4%	98%
Geauga, OH	2,837	2%	100%

Table 4b. County-Level POM Emissions

County, State	Emissions in average tons/yr		
	POM	Pct.	Cumulative %
Cuyahoga, OH	2,166	32%	32%

⁴⁹ Data are based on the 2011 and 2018 Emissions Modeling Platform Data Files and Summaries (<ftp://ftp.epa.gov/EmisInventory/2011v6/v1platform>) available at: <http://www.epa.gov/ttn/chief/emch/index.html#2011> (accessed 02/26/14).

Summit, OH	857	13%	44%
Stark, OH	738	11%	55%
Lake, OH	593	9%	64%
Lorain, OH	525	8%	71%
Wayne, OH	418	6%	78%
Medina, OH	407	6%	84%
Ashtabula, OH	404	6%	89%
Portage, OH	390	6%	95%
Geauga, OH	329	5%	100%

Table 4c. County-Level Elemental Carbon Emissions

County, State	Emissions in average tons/yr		
	EC	Pct.	Cumulative %
Cuyahoga, OH	946	28%	28%
Summit, OH	451	13%	42%
Lake, OH	396	12%	53%
Stark, OH	375	11%	65%
Lorain, OH	317	9%	74%
Portage, OH	201	6%	80%
Ashtabula, OH	194	6%	86%
Wayne, OH	186	6%	91%
Medina, OH	178	5%	97%
Geauga, OH	112	3%	100%

Table 4d. County-Level PNO3 Emissions

County, State	Emissions in average tons/yr		
	PNO3	Pct.	Cumulative %
Cuyahoga, OH	17	39%	39%
Stark, OH	6	13%	52%
Lorain, OH	4	9%	62%
Lake, OH	4	9%	70%
Summit, OH	3	7%	77%
Ashtabula, OH	3	6%	83%
Wayne, OH	3	6%	89%
Portage, OH	2	5%	94%
Medina, OH	1	3%	97%
Geauga, OH	1	3%	100%

Table 4e. County-Level SO2 Emissions

County, State	Emissions in average tons/yr		
	SO2	Pct.	Cumulative %

Lake, OH	52,697	44%	44%
Lorain, OH	32,558	27%	71%
Wayne, OH	18,028	15%	86%
Cuyahoga, OH	6,916	6%	92%
Summit, OH	4,310	4%	96%
Ashtabula, OH	3,765	3%	99%
Stark, OH	566	<1%	
Geauga, OH	261	<1%	
Portage, OH	170	<1%	
Medina, OH	162	<1%	100%

Table 4f. County-Level PSO4 Emissions

County, State	Emissions in average tons/yr		
	PSO4	Pct.	Cumulative %
Lake, OH	445	41%	41%
Cuyahoga, OH	184	17%	58%
Stark, OH	124	11%	70%
Wayne, OH	106	10%	79%
Lorain, OH	101	9%	89%
Ashtabula, OH	48	4%	93%
Summit, OH	36	3%	96%
Portage, OH	15	1%	98%
Medina, OH	12	1%	99%
Geauga, OH	11	1%	100%

In addition to reviewing county-wide emissions of PM_{2.5} and PM_{2.5} precursors in the area of analysis, EPA also reviewed emissions from major point sources located in the area of analysis. The magnitude and location of these sources can help inform nonattainment boundaries. Table 5 provides facility-level emissions of direct PM_{2.5}, components of direct PM_{2.5}, and precursor pollutants (given in tons per year) from major point sources located in the area of analysis for the Cleveland area. Table 5 also shows the distance from the facility to the 2011-2013 DV monitor for the respective county.

Table 5. NEI 2011 v1 Point Source Emissions (tons/year)

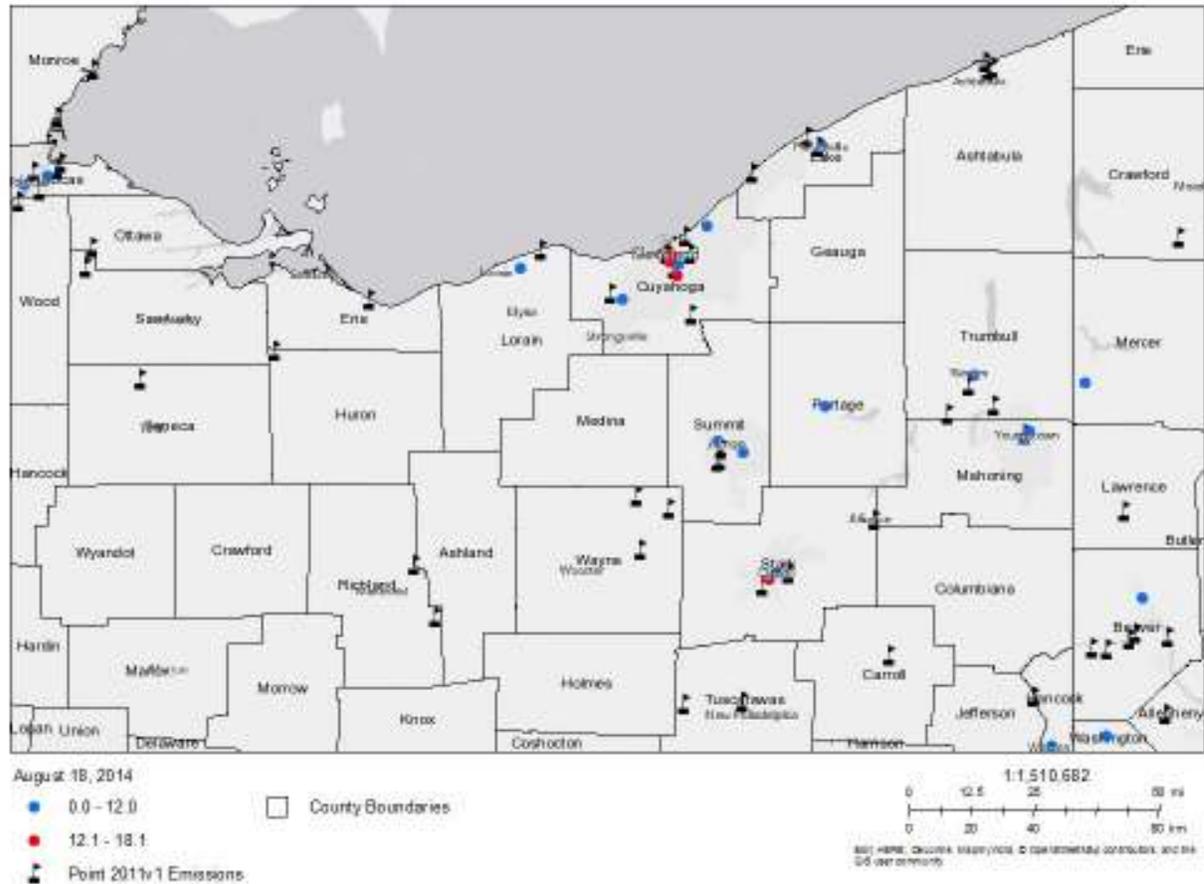
County, State	Facility Name (Facility ID)	Distance monitor (miles)	NEI 2011 v1 Emissions - Tons/Year					Total
			NH3	NOx	PM2.5	SO2	VOC	
Ashtabula, OH	Millennium Inorganic Chemicals, Inc. - Plant 2 (0204010193)	55	1	193	62	8	1,697	1,962

County, State	Facility Name (Facility ID)	Distance monitor (miles)	NEI 2011 v1 Emissions - Tons/Year					
			NH3	NOx	PM2.5	SO2	VOC	Total
Ashtabula, OH	Millennium Inorganic Chemicals, Inc. Plant #1 (0204010200)	56	1	40	11	14	733	799
Ashtabula, OH	FirstEnergy Generation Corp., Ashtabula Plant (0204010000)	56	0	1,148	317	3,454	17	4,937
Cuyahoga, OH	DiGeronimo Aggregates LLC (1318270383)	9	0	69	78	524	1	671
Cuyahoga, OH	ArcelorMittal Cleveland Inc. (1318001613)	1	11	1,165	553	723	94	2,546
Cuyahoga, OH	Cleveland Electric Illuminating Co., Lake Shore Plant (1318000245)	4	0	771	66	1,942	11	2,791
Cuyahoga, OH	Cleveland Thermal LLC (1318000246)	1	0	252	69	930	2	1,253
Cuyahoga, OH	The Medical Center Company (1318003059)	3	0	204	38	2,133	4	2,379
Cuyahoga, OH	Cleveland-Hopkins Intl (XXXXXXXXXX)	10	0	599	21	75	137	833
Lake, OH	Carmeuse Lime, Inc - Grand River Operations (0243030257)	28	0	520	18	891	3	1,432
Lake, OH	PAINESVILLE MUNICIPAL ELECTRIC PLANT (0243110008)	28	0	509	150	2,745	2	3,406
Lake, OH	CLEVELAND ELECTRIC ILLUMINATING CO., EASTLAKE PLANT (0243160009)	18	1	8,446	4,023	48,300	103	60,873
Lorain, OH	Avon Lake Power Plant (0247030013)	19	1	4,659	394	32,041	30	37,125
Stark, OH	Alliance Casting Co. LLC (1576010014)	49	0	614	216	3	33	865
Stark, OH	Republic Engineered Products, Inc. (1576050694)	50	2.2	224	174	63	66	529
Stark, OH	Marathon Petroleum Company LP - Canton Refinery (1576002006)	50	8	285	188	93	224	798
Summit, OH	Cargill, Incorporated - Salt Division (Akron, OH) (1677010027)	30	0	140	18	1,516	1	1,676
Summit, OH	Emerald Performance Materials, LLC (1677010029)	49	0	115	1	869	10	996
Summit, OH	City of Akron Steam Generating (1677010757)	47	0	254	44	1,729	2	2,028
Wayne, OH	Department of Public Utilities, City of Orrville, Ohio (0285010188)	70	0	1,902	745	13,038	5	15,690
Wayne, OH	Morton Salt, Inc. (0285020059)	57	0	195	50	4,434	2	4,681
Wayne, OH	East Ohio Gas - Chippewa Station (0285000366)	60	0	654	13	0	23	690

Figure 5 shows the major point source emissions (from the 2011 NEI in tons per year) in the area of analysis for the Cleveland area and the distances of these sources from the violating monitoring locations, as depicted by red dots in Cuyahoga County. The actual distance from the point sources to the DV monitoring location is presented in Table 5). The distance from the violating monitoring location is particularly important for directly emitted PM_{2.5}. The influence of directly emitted PM_{2.5} on ambient PM_{2.5} diminishes more than that of gaseous precursors as a function of distance.⁵⁰

⁵⁰ Baker, K. R. and K. M. Foley. *A nonlinear regression model estimating single source concentrations of primary and secondarily formed PM_{2.5}*. Atmospheric Environment. 45 (2011) 3758-3767.

Figure 5. Major Point Source Emissions in the Area of Analysis for the Cleveland Area.



In summary, EPA’s analysis of relevant county-level emissions and the geographic locations of the relevant pollutants shows that about 59% of the directly emitted and precursor emissions, in the area of analysis, come from Lake, Cuyahoga, and Lorain Counties, with the highest emissions from Lake County. As discussed more fully under Factor 3, the winds are generally from the south through west, further minimizing the impact of Ashtabula, Portage and Geauga Counties on the violating monitors in Cleveland. Lake County, which is adjacent to Cuyahoga County, emits 27% of the direct PM_{2.5} from the area of analysis and Cuyahoga County, where the violating monitors are located, emits 21% of the direct PM_{2.5}.

Although Stark County has recorded violations of the 2013 PM_{2.5} standard, it is in a separate metropolitan area (the Canton-Massillon area), and this county has historically been designated as a separate nonattainment area under both the 1997 annual PM_{2.5} standard and the 2006 24-hour PM_{2.5} standard as well as for various ozone standards. Furthermore, emissions from Wayne and Summit counties contribute more to Stark County than to Cuyahoga County. Therefore, as discussed in the section of this document pertaining to the Canton-Massillon area, Stark and Summit County, as well as part of Wayne County are being included in the Canton-Massillon area; not in the Cleveland area.

The impact of PM_{2.5} from Ashtabula, Geauga and Portage Counties is limited by location and emission levels. Geauga is adjacent to Cuyahoga County, but only emits 3% of direct PM_{2.5} and only 2% of the combined total directly emitted and precursor emissions from the area of analysis. Ashtabula County only emits 5% of both the total direct PM_{2.5} and combined total directly emitted and precursor emissions from the area of analysis and Portage County only emits 4% of both the total direct PM_{2.5} and combined total directly emitted and precursor emissions from the area of analysis. In addition, all of these counties are east of Cuyahoga County, further reducing their impact.

As seen in Tables 4a–f, Cuyahoga, Lake, Lorain, Summit, and Wayne counties all consistently ranked in the highest percentages of directly emitted PM_{2.5} and precursors. Cuyahoga County accounts for 27% of the NO_x emissions, 32% of POM emissions, 28% of EC emissions, 39% of PNO₃ emissions, 6% of SO₂ emissions and 17% of PSO₄ emissions in the area of analysis. Lake County contributes 14% of NO_x, 9% of POM, 12% of EC, 9% of PNO₃, 44% of SO₂ and 41% of PSO₄ emissions in the area of analysis. Summit County contributes 11% of NO_x, 13% of POM, 13% of EC, 7% of PNO₃, 4% of SO₂ and 3% of PSO₄ emissions in the area of analysis. Lorain County contributes 12% of NO_x, 8% of POM, 9% of EC, 9% of PNO₃, 27% of SO₂, and 9% of PSO₄ emissions in the area of analysis. Wayne County contributes 6% of NO_x, 6% of POM, 6% of EC, 6% of PNO₃, 15% of SO₂, and 10% of PSO₄ emissions in the area of analysis. All of these counties, but Lake, are upwind of the area of analysis. By contrast, Medina, Portage, and Geauga counties consistently ranked in the lowest percentages of directly emitted PM_{2.5} and precursors within the area of analysis.

As indicated in Figure 5, there are 22 point sources located within 70 miles of the violating monitor. The largest source is in Lake County, with the next largest sources found in Lorain and Wayne Counties. The source in Lake County is only 18 miles from the violating monitor and accounts for 71% of the total emissions in Lake County. There are 6 point sources within 10 miles of the violating monitor and most of the others are about 30 or more miles away from the violating monitor. About 14% of the point source direct PM_{2.5} and precursor emissions are from the point sources in Wayne County. However, as discussed in the section on the Canton-Massillon Nonattainment Area, Summit and the industrialized portion of Wayne Counties are included as part of the intended Canton-Massillon Nonattainment Area. As explained below, this is because those counties contributed more to the violating monitor in Stark County than to the violating monitors in Cuyahoga County.

Population density and degree of urbanization

In this part of the factor analysis, EPA evaluated the population and vehicle use characteristics and trends of the area as indicators of the probable location and magnitude of non-point source emissions. Rapid population growth in a county on the urban perimeter signifies increasing integration with the core urban area, and indicates that it may be appropriate to include the county associated with area source and mobile source emissions as part of the nonattainment area. Table 6 shows the 2000 and 2010 population, population growth since 2000, and population density for each county in the area.

Table 6. Population Growth and Population Density.

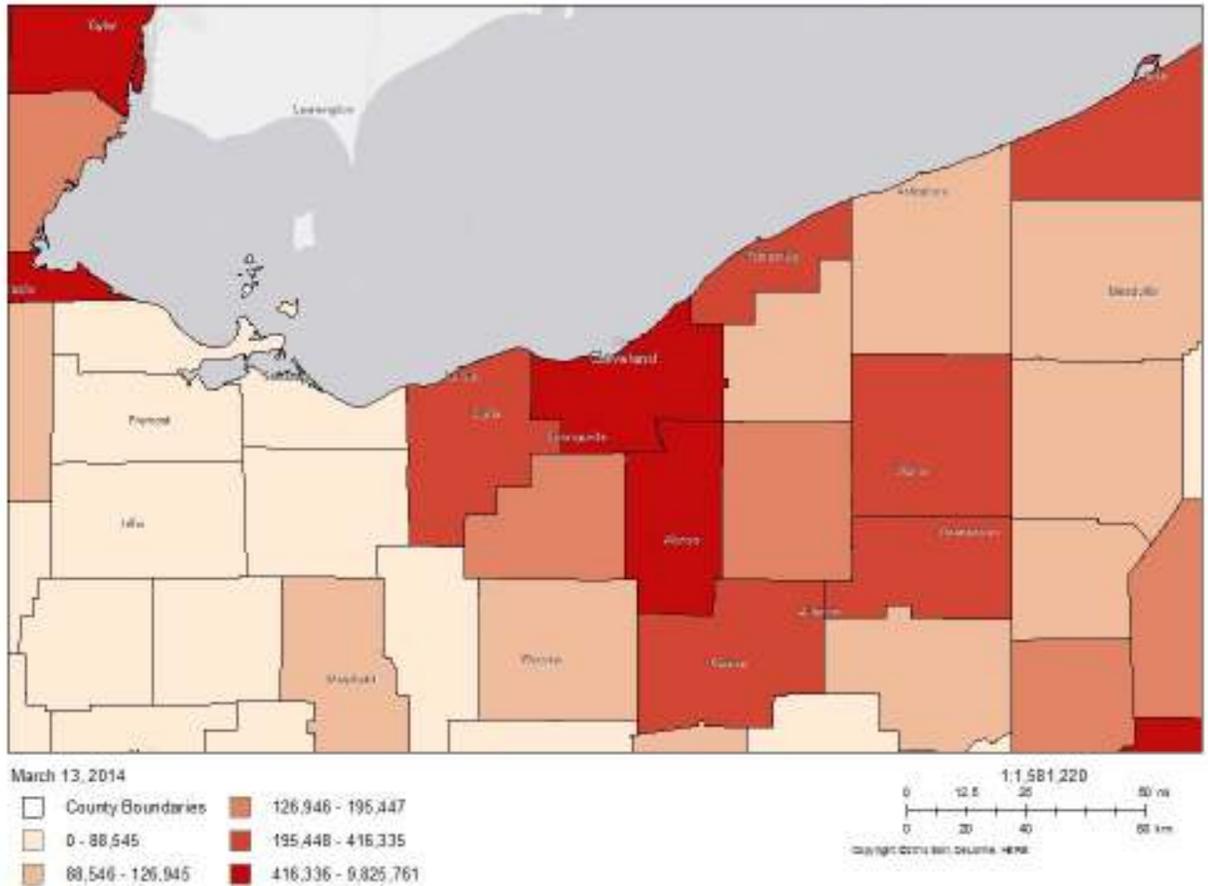
County, State	Population 2000	Population 2010	% Change from 2000	Land Area (Sq. Miles)	Population Density (per Sq. Mile)	%	Cumulative %
Cuyahoga, OH	1,393,978	1,278,466	-8.3%	458	2,788	38	38

Summit, OH	542,899	541,652	-0.2%	413	1,312	16	54
Stark, OH	378,098	375,417	-0.7%	576	652	11	65
Lorain, OH	284,664	301,533	5.9%	493	612	9	74
Lake, OH	227,511	230,054	1.1%	228	1,008	7	81
Medina, OH	151,095	172,656	14.2%	422	409	5	86
Portage, OH	152,061	161,403	6.1%	492	328	5	91
Wayne, OH	111,564	114,480	2.6%	555	206	3	94
Ashtabula, OH	102,728	101,425	-1.3%	702	144	3	97
Geauga, OH	90,895	93,398	2.8%	404	231	3	100
Total	3,435,493	3,370,393					

Source: U.S. Census Bureau population estimates for 2000 and 2010

Cuyahoga County has the largest population, population density and is the largest percent urban. Cuyahoga, Summit, Stark, Lorain, Lake and Medina Counties contain 86% of the population in the area of analysis. Cuyahoga, Summit and Lake Counties have the highest population densities whereas Medina, Portage, Wayne, Ashtabula and Geauga have the lowest population densities. Cuyahoga has the highest population at 1,278,466 and Summit County has the next highest population at 541,652. These two counties contain 54% of the total population in the area of analysis. Medina, Portage, Wayne, Ashtabula, and Geauga Counties contain less than 20% of the total population. Cuyahoga, Summit and Lake Counties have population densities over 1000 per square mile whereas Ashtabula, Wayne and Geauga Counties have population densities less than 250 per square mile.

Figure 6. 2010 County-Level Population in the Area of Analysis for the Cleveland Area.



Traffic and Vehicle Miles Travelled

High vehicle miles travelled (VMT) and/or a high number of commuters associated with a county is generally an indicator that the county is an integral part of an urban area. Mobile source emissions of NO_x, VOC, and direct PM may contribute to ambient particulate matter that contributes to monitored violations of the NAAQS in the area. In combination with the population/population density data and the location of main transportation arteries, an assessment of VMT helps identify the probable location of nonpoint source emissions that contribute to violations in the area. Comparatively high VMT in a county outside of the CBSA or CSA signifies integration with the core urban area contained within the CSA or CBSA, and indicates that a county with the high VMT may be appropriate to include in the nonattainment area because emissions from mobile sources in that county contribute to violations in the area. Table 7 shows 2011 VMT while Figure 7 overlays 2011 county-level VMT with a map of the transportation arteries. The VMT used in this analysis was submitted by Ohio.

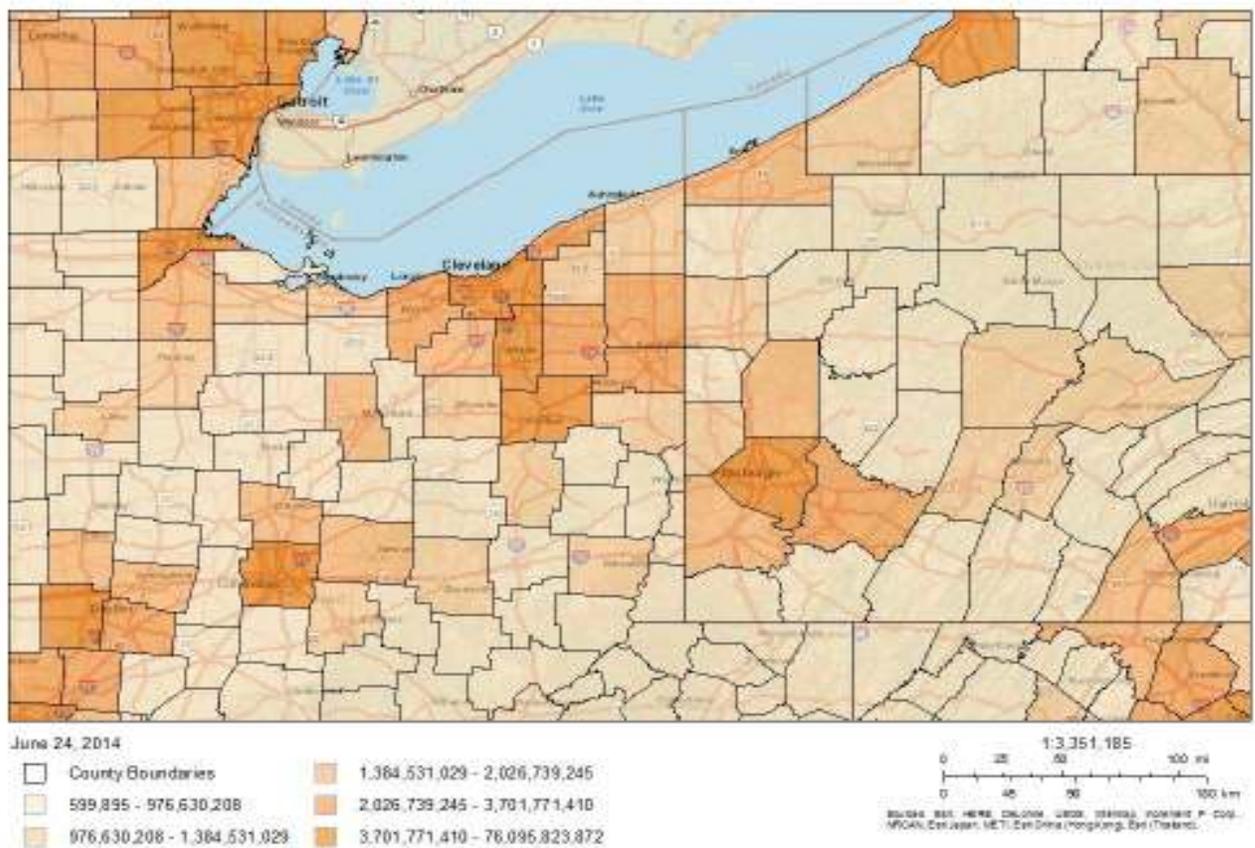
Table 7. 2011 VMT for the Cleveland Area.

County, State	Total 2011 VMT	Percent	Cumulative %
Cuyahoga, OH	8,534,134,941	27	27
Summit, OH	6,250,389,061	20	47
Stark, OH	3,838,738,336	12	60

Lorain, OH	2,787,828,581	9	69
Lake, OH	2,461,578,196	8	77
Portage, OH	2,128,490,347	7	83
Medina, OH	1,774,539,943	6	89
Wayne, OH	1,192,145,098	4	93
Ashtabula, OH	1,137,086,286	4	97
Geauga, OH	1,045,092,778	3	100
Total	31,150,023,566		

<http://www.census.gov/hhes/commuting/data/commuting.html>

Figure 7. Overlay of 2011 County-level VMT with Transportation Arteries.



Cuyahoga and Summit Counties have the highest and second highest VMT and account for 47% of the total VMT in the area of analysis. These are followed by Stark, Lorain, Lake, Portage, Medina, Wayne, Ashtabula, and Geauga Counties. As previously discussed, Stark County, Summit County, and part of Wayne County are being considered in the evaluation of the Canton-Massillon area instead of the Cleveland area because they contribute more to the violation in Stark County than to the violations in Cuyahoga County. Of the counties being considered as part of the Cleveland area, there is a big gap between the VMT for Cuyahoga County (8,534,134,941) versus the remaining counties, with Lorain County having the next highest (2,787,828,581) and the rest gradually decreasing to Geauga County as the lowest (1,045,092,778).

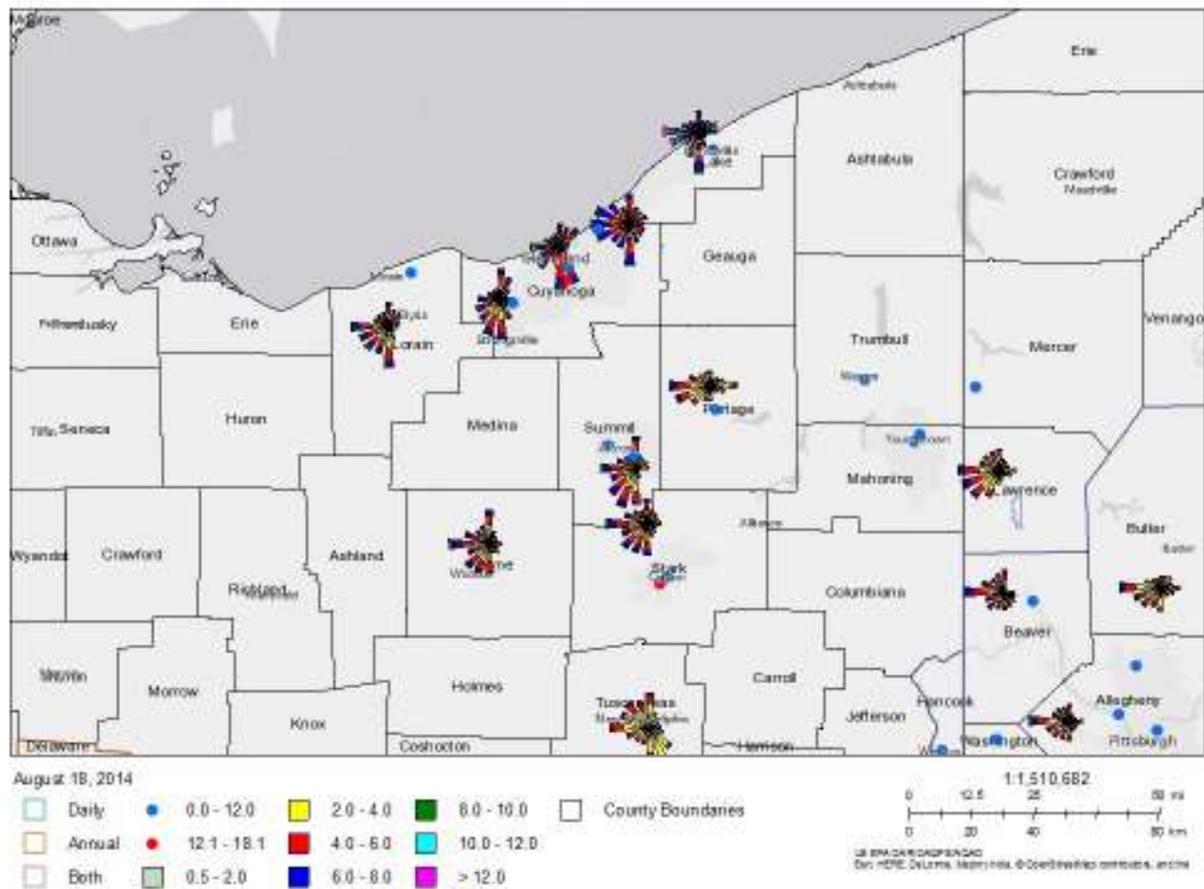
Factor 3: Meteorology

EPA evaluated available meteorological data to determine how meteorological conditions, including, but not limited to, weather, transport patterns, and stagnation conditions, could affect the fate and transport of directly emitted particulate matter and precursor emissions from sources in the area of analysis. EPA used two primary tools for this assessment: wind roses and kernel density estimation (KDE). When considered in combination with area PM_{2.5} composition and county-level and facility emissions source location information, wind roses and KDE can help to identify nearby areas contributing to violations at violating monitoring sites.

Wind roses are graphic illustrations of the frequency of wind direction and wind speed. Wind direction can indicate the direction from which contributing emissions are transported; wind speed can indicate the force of the wind and thus the distance from which those emissions are transported. EPA constructed wind roses from hourly observations of wind direction and wind speed using 2009-2012 data from National Weather Service locations archived at the National Climate Data Center.⁵¹ When developing these wind roses, EPA also used wind observations collected at meteorological sampling stations collocated at air quality monitoring sites, where these data were available. Figure 8 shows wind roses that EPA generated from data relevant in the Cleveland area.

⁵¹ <ftp.ncdc.noaa.gov/pub/data/noaa> or <http://gis.ncdc.noaa.gov/map/viewer/#app=cdo&cfg=cdo&theme=hourly&layers=1&node=gis> Quality assurance of the National Weather Service data is described here: <http://www1.ncdc.noaa.gov/pub/data/inventories/ish-qc.pdf>

Figure 8. Wind Roses in the Area of Analysis for the Cleveland Area.

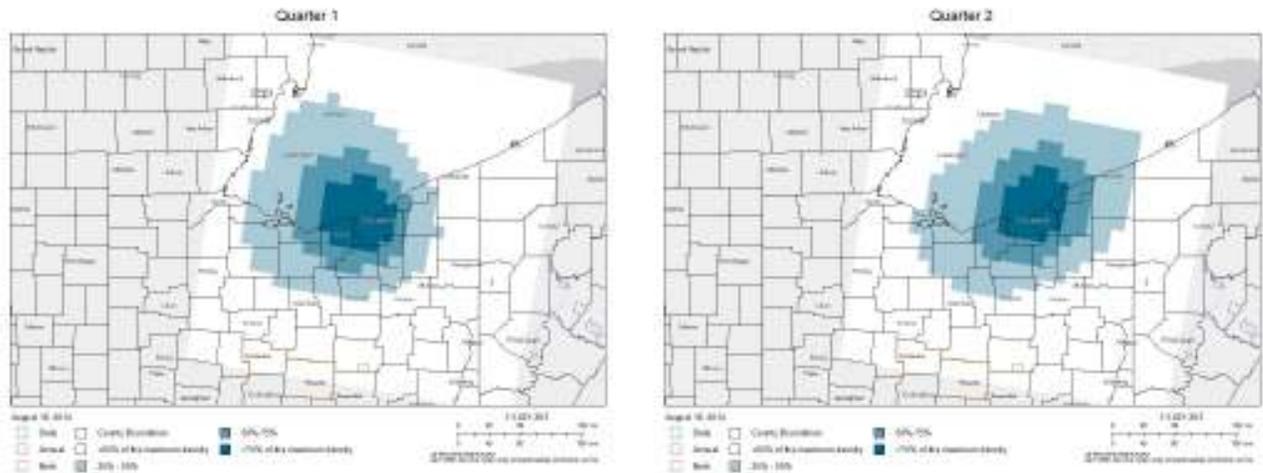


As shown in Figure 8, there is a pattern across the area of predominantly south to west winds, mostly at mid-level speeds of 4 to 10 meters per second, suggesting that potential emission sources in the south-through-west upwind direction should be considered for analysis.

In addition to wind roses, EPA also generated kernel density estimation (KDE) plots to represent HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) backward trajectory frequency at violating

monitoring sites.^{52,53} These KDEs are graphical statistical estimations to determine the density of trajectory endpoints at a particular location represented by a grid cell. The EPA used KDEs to characterize and analyze the collection of individual HYSPLIT backward trajectories.⁵⁴ Higher density values, indicated by darker blue colors, indicate a greater frequency of observed trajectory endpoints within a particular grid cell. Figure 9 shows a HYSPLIT KDE plot for the Cleveland area summarized by calendar quarter for the 2010-2012 period. The HYSPLIT KDE is weighted in the west to southerly direction, indicating a greater frequency of trajectories passing over grid cells to the west and south.

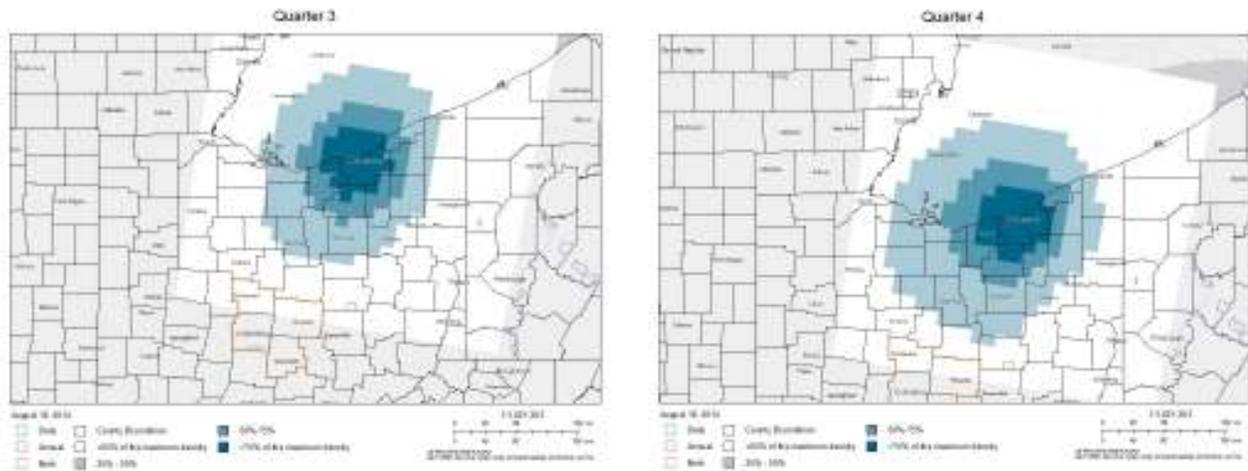
Figure 9. HYSPLIT Kernel Density Estimation Plots for the Cleveland Area.



⁵² In some past initial area designations efforts, EPA has used HYSPLIT backward trajectories to assist in determining nonattainment area boundaries. A HYSPLIT backward trajectory is usually depicted on a standard map as a single line, representing the centerline of an air parcel's motion, extending in two dimensional (x,y) space from a starting point and regressing backward in time to a point of origin. Backward trajectories may be an appropriate tool to assist in determining an air parcel's point of origin on a day in which a short-term standard, such as an 8-hour standard or a 24-hour standard, was exceeded. However, for an annual standard, such as the 2012 annual PM_{2.5} NAAQS, every trajectory on every day is important. Plotting a mass of individual daily (e.g., 365 individual back trajectories), or more frequent, HYSPLIT trajectories may not be helpful as this process is likely to result in depicting air parcels originating in all directions from the violating monitoring site.

⁵³ HYSPLIT - Hybrid Single Particle Lagrangian Integrated Trajectory Model, http://www.arl.noaa.gov/HYSPLIT_info.php

⁵⁴ The KDEs graphically represent the aggregate of HYSPLIT backward trajectories for the years 2010-2012, run every third day (beginning on the first day of monitoring), four times each day, and ending at four endpoint heights.



In summary, for the violating Cleveland monitor, the HYSPLIT KDE plots and wind roses suggest greatest potential contribution of emissions from Cuyahoga, Lorain, Summit, Wayne and Medina Counties. The HYSPLIT KDE plots indicate low density values in Ashtabula County. As discussed in the emission discussion, Medina has a relatively small amount of relevant contributing emissions, and Wayne County are being considered as part of the Canton-Massillon area nonattainment area.

Factor 4: Geography/topography

To evaluate the geography/topography factor, EPA assessed physical features of the area of analysis that might define the airshed and thus affect the formation and distribution of PM_{2.5} concentrations over the area.

The Cleveland area does not have any geographical or topographical barriers known to significantly limit air pollution transport around the area of analysis. Therefore, this factor did not play a significant role in defining the boundary of the intended area.

Factor 5: Jurisdictional boundaries

In defining the boundaries of the intended Cleveland nonattainment area, EPA considered existing jurisdictional boundaries, which can provide easily identifiable and recognized boundaries for purposes of implementing the NAAQS. Existing jurisdictional boundaries often signify well recognized boundaries that the state can easily administer and for which the state has the necessary legal authority for carrying out air quality planning and enforcement functions. Examples of such jurisdictional boundaries include existing/prior nonattainment area boundaries for particulate matter, county lines, air district boundaries, township boundaries, areas covered by a

metropolitan planning organization, state lines, and Reservation boundaries, if applicable. Where existing jurisdictional boundaries were not adequate or appropriate to describe the nonattainment area, EPA considered other clearly defined and permanent landmarks or geographic coordinates for purposes of identifying the boundaries of the intended designated areas.

The Cleveland area has previously established nonattainment boundaries associated with the 1997 and 2006 PM_{2.5} NAAQS. Ashtabula (partial county), Cuyahoga, Lake, Lorain, Medina, Portage and Summit Counties were designated as nonattainment for the 1997 annual standard and Cuyahoga, Lake, Lorain, Medina, Portage and Summit Counties were designated as nonattainment of the 2006 24-hour standard. Ohio recommended that only Cuyahoga County be designated as nonattainment of the 2012 PM_{2.5} annual PM_{2.5} NAAQS.

EPA is removing Ashtabula County and Portage Counties from the 2012 nonattainment area because their emissions are relatively low and they are not upwind of Cleveland. Summit County and part of Wayne County are being considered as part of the Canton-Massillon area.

Conclusion for Cleveland Area

Based on the assessment of factors described above, both individually and in combination, EPA has preliminarily concluded that the following counties should be included as part of the Cleveland nonattainment area because they are either violating the 2012 annual PM_{2.5} NAAQS or contributing to a violation in a nearby area: Cuyahoga, Lake, and Lorain Counties. These are not the same counties that were included in the Cleveland-Akron-Lorain nonattainment area for the 2006 24-hour or the 1997 annual PM_{2.5} NAAQS. The air quality monitoring sites in Cuyahoga County indicate violations of the 2012 annual PM_{2.5} NAAQS based on the 2013 DVs; therefore this county is included in the nonattainment area. Lake and Lorain Counties are nearby counties that do not have violating monitoring sites, but EPA has concluded that these areas contribute to the particulate matter concentrations in violation of the 2012 annual PM_{2.5} NAAQS through emissions from point sources and other non-point sources (e.g., area sources), and from mobile source emissions. Because of a greater contribution to the violating monitor in Stark County than in Cuyahoga County, Summit and part of Wayne County are being included as part of the Canton-Massillon Area. Lake, Cuyahoga, and Lorain Counties have the highest emissions of directly emitted PM_{2.5} and/or PM_{2.5} precursors in the area and Lorain County is upwind of and contributes significantly to the violating monitors in Cleveland.

Cuyahoga County has violating monitors and has been recommended as nonattainment by Ohio. Lake County emits the greatest amount of directly emitted PM_{2.5} and precursors in the Cleveland area, including 44% of the SO₂ emissions and has a high population density. The Eastlake Plant of the Cleveland Electric Illuminating company has the highest combined emissions of any source in the Cleveland area and is only 18 miles from the design value monitor in Cleveland. Lorain County emits the third highest amount of directly emitted PM_{2.5} and precursors in the Cleveland area. It emits 32% of the SO₂ emissions in the Cleveland area. Lake County and Lorain Counties combined contribute over 75% of the SO₂ emissions in the Cleveland area and are therefore considerable contributors to the sulfate urban increment, which is between 0.3-4 ug/m³ for quarters 1,2 and 4. The Avon Lake Power Plant emits the second highest amount of combined emissions in the area and is only 19 miles from the violating design value monitor in Cleveland. Lorain County is southwest, and upwind, of Cleveland and is therefore a considerable contributor to the violating monitors in Cleveland. In summary, Lake County has the highest combined emissions of any County and is adjacent to Cuyahoga County, which has the violating monitors. The wind roses and kernel densities indicate that Lorain is a considerable contributor to the violating monitors in Cleveland.